Recent Advances In Otolaryngology

Balasubramanian Thiagarajan

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About The Author

Dr Balasubramanian Thiagarajan currently Professor of Otolaryngology Stanley Medical College Chennai has authored a number of books on otolaryngology. His passion is web based teaching. He is currently maintaining Nine sites providing E- Learning resources to students and practitioners of Otolaryngology.

Sites maintained by the author:

www.drtbalu.com
www.drtbalu.co.in
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www.entscholar.com
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Tinnitus Management using intratympanic Medications

Definition:

Tinnitus is defined as abnormal sound heard in the ear. It can be divided into two types:

Subjective tinnitus: where the sound is heard only by the patient and not by the physician.

Objective tinnitus: Is heard both by the patient as well as the examining physician. One common example of objective tinnitus is palatal myoclonus.

The term tinnitus is derived from the Latin word tinnire which translated means ringing sound. Tinnitus can occur alone or in combination with sensorineural hearing loss. People affected belong to the 5th and 6th decade age groups. It is a very difficult condition to manage because of its multifactorial etiology.

Management of tinnitus an overview:

Tinnitus could be managed by:

1. Hearing amplification (use of hearing aids)

2. Use of tinnitus maskers

3. Use of oral drugs

4. Tinnitus retraining therapy

To this list recently intra tympanic medications have also been added. This should infact be considered in selected cases.

Schuknecht first used intra tympanic aminoglycosides (Streptomycin) for treatment of Meniere's disease. Because of its ototoxic effects this therapy had immediate effect on tinnitus. Beck later used gentamycin in tinnitus management. This drug gained in popularity because of its ability to preserve hearing. Lignocaine and steroids were also used with success in the management of tinnitus.

Use of intratympanic lignocaine in the management of tinnitus:

Lignocaine belongs to a drug group called amides. Its mechanism of action is through sodium channel blockade at the level of neurons. It also has a profound analgesic, antiarrythmic and anticonvulsant properties. It has this unique ability to silence the hyperactive neurons responsible for the production of tinnitus.

Eventhough it was highly effective in the management of tinnitus, it had certain unpleasant side effects like vertigo, nausea and vomiting which necessitated hospitalisation of the patient.

Use of intratympanic corticosteriods in the management of tinnitus:

Corticosteriods are well known for its anti inflammatory property. Steriod receptors have been demonstrated in the inner ear. It also increases the blood supply to the cochlea. It is this property which has been attributed as the cause for its effect on tinnitus. The advantages of intra tympanic adminsitration of steriods is as follows:

1. When administered intra tympanically, it is devoid of its systemic toxic effects.

2. There is an immediate increase in concentration of this drug in the inner ear. There is virtually no latent period.

Methylpredinsolone has been found to have the best effect in the reduction of tinnitus because of its ability to penetrate into the inner ear fluids though the round window membrane.

Factors influencing the passage of drugs through the round window:

1. Normal round window membrane

2. Presence of inflammation around round window membrane increases its permeability to the drug.

3. Obstruction due to eustachean tube block: This allows the drug to stay a long time within the middle ear cavity facilitating inner ear penetration via the round window membrane.

4. Molecular weight of the drug administered: Lesser the molecular weight of the drug better is the penetration.

5. Liposolubility: The more liposoluble the drug the better is its penetration through the round window membrane.

Diagram showing Silverstein Microwick

Studies have shown that steriods have better effects in controlling the tinnitus caused by Meniere's disease, while lignocaine has better effect in controlling tinnitus associated with labyrinthine vertigo.

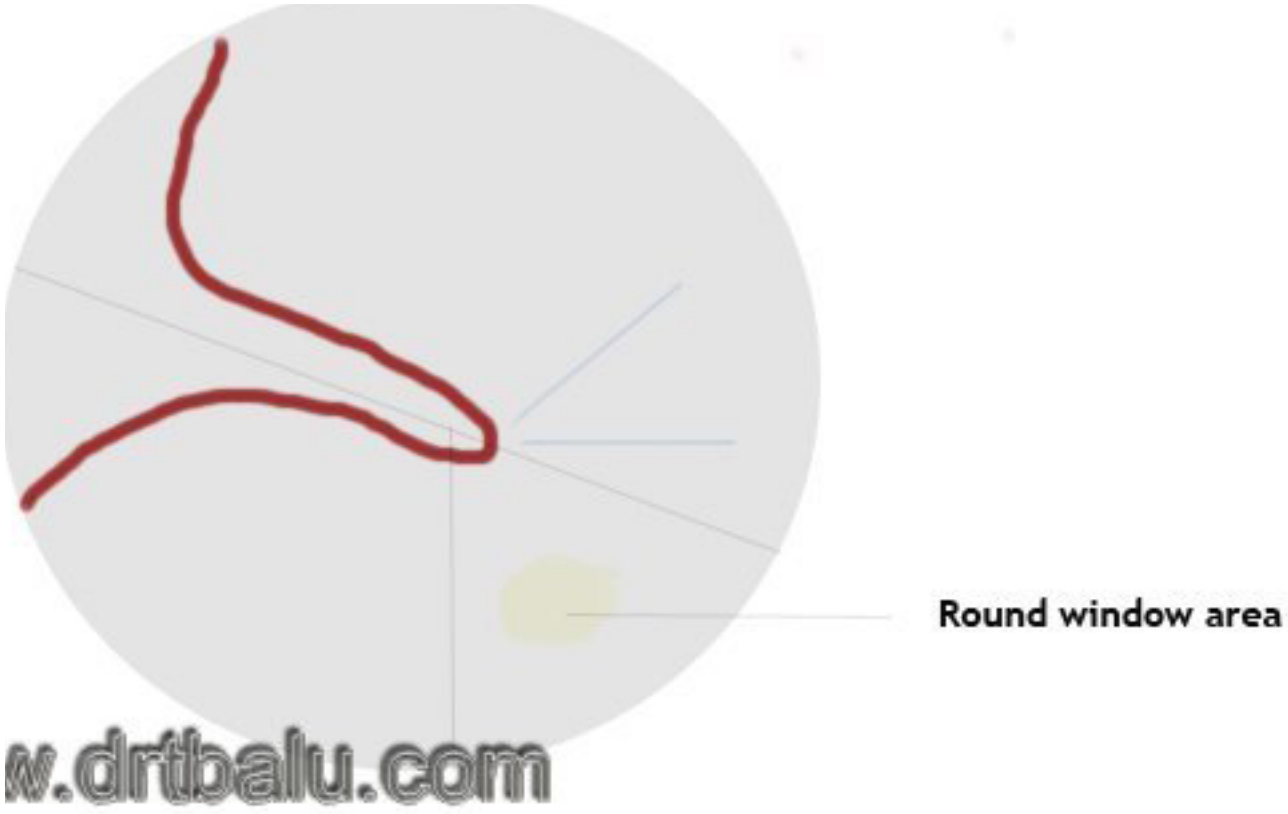
Dexamethasone can be perfused through the middle ear in a dose of 4mg/ml. This drug can be instilled into the middle ear through a tympanotomy incision. Injections can be repeated once a week till the patient is symptom free. Grommets can be introduced to facilitate repeated injections of this drug.

Gentamycin can be administered intra tympanically in doses of 40mg/ml. It can be repeated at weekly intervals till the patient is symptom free.

Modern middle ear drug delivery systems:

The aim of this delivery system is to predictably deliver drug directly over the round window membrane to facilitate easy absorption. The Silverstein micro wick has been specifically designed for this purpose. The main advantage of this system is that after the initial administration of the drug by the physician the patient himself can administer the drugs at home at specified intervals. The microwick absorbs the medication and transports it directly to the round window membrane.

The microwick is made up of polyvinyl acetate. It measures 1mm in diameter and about 9mm long. It can be easily inserted through a grommet. As a first step grommet must be inserted into the round window area under local anesthesia. Round window niche is identified as a dark area just posterior and inferior to the umbo. Microwick can easily be inserted through this ventilation tube in such a way that it lies in contact with the round window membrane. After the first administration of the drug patient himself can administer the drug as ear drops two or three times a day as advised. The only precaution is that the patient must lie with the drug adminstered ear facing up for at least 5 minutes to enable adequate drug perfusion into the middle ear.



After treatment the microwick can easily be removed without anesthesia using a micro cup forceps.

Indications for intratympanic medications:

1. Meniere's disease

2. Sudden sensori neural deafness (steriod is used)

3. Tinnitus

Complications of intratympanic medications:

1. Intense giddiness

2. Vomiting

3. Middle ear infection

4. Residual perforation

Pitfalls of microwick therapy:

1. Accurate placement of the microwick over the round window area is a must.

2. Laser tympanotomy is preferred to conventional one because of the blood less field. This is a must for accurate placement of the wick. When the area is moist insertion of the wick becomes difficult because it swells up on exposure to moisture.

Hyperbaric oxygen therapy

Definition: Hyperbaric oxygen therapy is defined as administration of 100% oxygen to a patient placed inside a chamber pressurised to greater than 1 atmosphere at sea level. Local application of pressurized oxygen to a part of the body without completely enclosing the patient is not hyper baric oxygen therapy.

History: In 1662 a British clergyman Henshaw first built a sealed chamber where compressed oxygen was given as a cure to various ailments. He also used the term Domicilium to describe the chamber. Following discovery of oxygen by Joseph Priestely it has been used to treat various chronic conditions at high pressures.

It was Dr I. Boerema in 1956 who demonstrated the value of oxygen under high pressure in management of certain difficult cardiovascular conditions.

Indications of Hyperbaric oxygen therapy:

1. Arterial air or gas embolism

2. Acute blood loss anaemia

3. Carbon monoxide poisoning, cyanide poisoning, and smoke inhalation

4. Compromised skin grafts and flaps

5. Crush injury

6. Decompression sickness

7. To facilitate enhanced wound healing

8. Gas gangrene

9. Necrotising soft tissue infections

10. Radiation necrosis: Osteoradionecrosis, soft tissue radionecrosis, caries in radiated bones

11. Refractory osteomyelitis

12. Refractory mycosis

13. Thermal burns

Mechanism of action:

1. Hyperoxygenation - is achieved by first completely saturating the hemoglobin and then by increasing the amount of oxygen dissolved in the plasma. This increases the distance of oxygen diffuses away from the capillaries. This is three times higher than under normal conditions.

2. Vasoconstriction - Vasoconstriction caused by hyperbaric oxygen therapy does not reduce oxygenation, on the contrary it has a benefical effect of reducing edema in skin grafts and flaps.

3. Anitmicrobial activity - Hyperbaric oxygen therapy is bactericidial to obligate anaerobes. It also increases the ability of polymorphs to kill bacteria. It is also known to inhibit and inactivate the toxins released by clostridium welchi, thereby preventing gas gangrene.

4. Pressure effects - Hyperbaric oxygen is used to reduce the size of gas bubble. Because of this feature it is the treatment of choice in decompression sickness.

5. Neovascularisation

6. Fibroblastic proliferation

7. Improved functioning of osteoblasts and osteoclasts

8. Increased red cell deformability

Complictions of hyperbaric oxygen therapy:

1. Middle ear barotrauma - This can occur if the patient is unable to equalise the middle ear pressure. This complication can be best avoided by the use of systemic and topical nasal decongestants before proceeding with hyperbaric oxygen therapy. If this condition occurs then myringotomy should be resorted to without hesitation.

2. Myopia - This is temporary and reverses back to normal after cessation of treatment.

3. Pneumothorax - can occur if decompression occur too rapidly or if the patient holds the breath during decompression.

4. Oxygen induced seizures - This complication is very rare. These patients should be given vitamin E before treatment to protect against superoxide radicals. Oxygen induced seizures can be stopped by allowing the patient to breath normal air. Oxygen induced seizures are not known to cause permanent neurological sequlae.

How to administer hyperbaric oxygen?

Hyperbaric oxygen is administered by placing the patient inside oxygen chambers. Two types of chambers are commonly used for hyperbaric oxygen therapy. 1. Monoplace and 2. Multiplace chambers. In both these chambers facilities are provided for monitoring the various vital body parameters like heart rate, blood pressure and blood oxygen levels etc. Facilities are provided for intravenous administration of drugs and fluids.

Monoplace chamber: Here 100% pressurised oxygen is utilized. Patient alone is placed in this type of chamber. There is no space for attendants. The patient is placed alone inside this chamber. This chamber is hence not useful in critically ill patients.

Regardless of the type of chamber used the following factors must be considered:

1. The amount of pressure used.

2. Duration of the treatment.

3. How often the treatment is repeated.

To avoid oxygen toxicity the treatment duration should not exceed 120 minutes. The safe range being 90 - 120 minutes. The pressure used is about 2 atmospheres. When a patient's condition require multiple hyperbaric oxygen treatments per day, a minimum duration of 6 hours between them is a must.
Indications of hyperbaric oxygen therapy:

1. Radiation induced soft tissue necrosis: Hyperbaric oxygen therapy promotes neovascularisation. Hypoxia is corrected and wound heals faster.

2. Osteoradionecrosis: Hyperoxygenation and neovascularisation helps in treating this difficult condition. Hyperbaric oxygen treatment is an effective adjuvant to antibiotics in managing this condition.

3. Prevention of mandibular osteoradionecrosis

4. In treating necrotising soft tissue infections

5. In management of malignant otitis externa

6. Can be used in management of fungal infections of head and neck. This has a proven value as an adjunct to the regular antifungal agents.

7. Managment of acute blood loss anaemia

8. Can be used to salvage compromised skin grafts and flaps

9. Can be used as an adjunct in the management of patients with burns

10. Can be used to manage air or gas embolism

Contraindications of hyperbaric oxygen therapy:

Absolute contraindications:

1. Pneumothorax

2. Pulmonary damage

Relative contraindications:

1. Pulmonary bulla

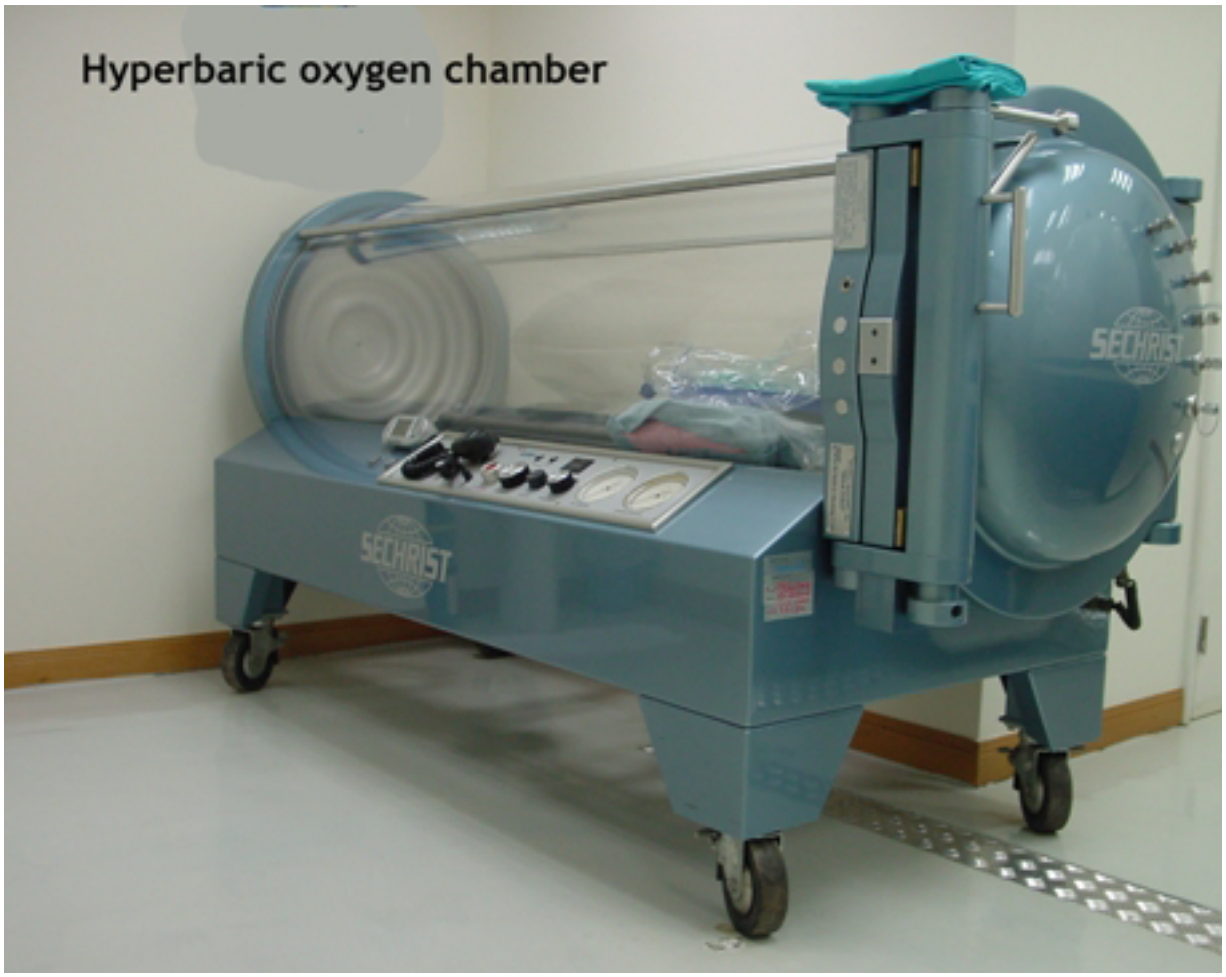
2. Seizure disorder

3. Patients on high dose of steroids

4. Chronic obstructive pulmonary disorders

5. Recent myocardial infarction

6. Patients with claustrophobia



Percutaneous Tracheostomy

Since the advent of open tracheostomy efforts were made to devise a procedure which will enable access into the trachea without a surgical incision or a minimal surgical incision. Percutaneous tracheostomy was devised with just this purpose in mind.

Advantages of percutaneous tracheostomy:

1. It is a simple procedure

2. Very easy to perform under emergency situations

3. Can be performed easily on the bed side

4. Can be performed by paramedics

Evolution of percutaneous tracheostomy:

The first tracheostomy technique that did not require neck dissection was first described by Sheldon in 1957. He used a specially designed slotted needle to blindly enter the tracheal lumen. This needle served as a guide for the introduction of a stillete and a metal tracheostomy tube.

In 1969 Toyee refined this technique making it incisional rather than dilational. In this technique after the trachea was cannulated using a needle, the tracheostomy tube was loaded on to a stiff wire boogie that contained a small recessed blade. This boogie along with the tracheostomy tube was advanced through the needle tract thereby placing the tracheostomy tube inside the trachea. This procedure was fraught with risks and para tracheal insertions occurred commonly and hence did not become popular.

In 1985 Ciaglia perfected the technique of percutaneous tracheostomy which is currently gaining popularity. He named this procedure dilational subcricoid percutaneous tracheostomy. (PDT). This technique has undergone three significant modifications:

1. The tracheal interspace for cannulation has been moved down by two rings caudal to the cricoid cartilage. This was done to prevent the development of subglottic stenosis.

2. Routine use of fibreoptic bronchoscopy has been advocated.

3. The use of single bevelled dilator has been substituted by the use of multiple dilators.

4. Can be performed by paramedics

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Paul's modification of Ciaglia technique:

This modification was introduced in 1989. Paul advocated the use of fibreoptic bronchoscope through the endotracheal tube to facilitate percutaneous tracheostomy.

The advantages of this modification are:

1. Use of bronchoscope allows for correct placement of tracheostome.

2. It ensures that the guide wire is introduced in a midline position.

3. It prevents damage to posterior tracheal wall during introduction of needle.

4. It helps in video recording the whole procedure for instructional purposes.

The major disadvantages of this modification are:

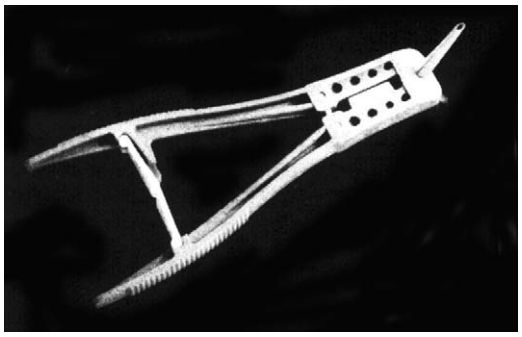
1. It involves more time.

2. More trained personal and special equipments are needed.

3. The procedure is more expensive.

To reduce the operating time a single curved dilator (Blue rhino dilator) is utilised instead of multiple dilators. Since this dilator is soft and has a more physiologic curvature it does not cause extensive damage to the soft tissues and the tracheal walls.

Rapitrach technique: This was first introduced in 1989 by Sachachner with an intention in facilitating a rapid tracheostomy. A special Rapitrach dilator was used. A rapitrach has two sharp blades designed in such a way that it slides over the guide wire and an opening is made when it is dilated. This procedure had a high incidence of damage to the membranous posterior tracheal wall. To avoid this complication in 1990 Griggs used a custom made forceps known as the Howard Kelly forceps. The tip of the forceps can be opened to create a tracheostome. In fact in all these methods the basic steps are the same but for modifications in the dilatation technique.



Rapitrach dilator

Translaryngeal tracheostomy:

This was first describe by Fanconi etal. The major aim of this procedure is to prevent damage to the posterior membranous wall of the trachea. The dilatation in Ciaglia technique is directed in a downward direction causing significant anteroposterior compression of the tracheal wall. Sometimes this compression is sufficient to cause rupture of the membranous posterior tracheal wall. In this technique this excess anteroposterior pressure is avoided since the tracheostomy tube is pulled upwards through the larynx in an inside out manner. The procedure is similar to Ciaglia technique till the introduction of a guide wire through the first and the second tracheal interspaces. The similarity ends here. The guide wire is passed through the needle into the larynx in a retrograde fashion, infact it traverses coaxially alongside the endotracheal tube till it reaches the oral cavity from where it is pulled out using a Magill's forceps. The aim of the next step is to create a room for the tracheostomy tube to traverse the larynx since an endotracheal tube is already in position. To achieve this the existing endotracheal tube in position is replaced with a smaller endotracheal tube using the same guide wire as a guide. The J tip (oral cavity end) of the guide wire is then attached to a special trocar and tracheostomy tube assembly. The guide wire is pulled through its neck end. This pulls the trocar along with the tracheostomy tube through the larynx into the trachea. Here excessive tension to the posterior tracheal wall is avoided. When the trocar causes tenting of skin in the neck a small incision is made over this tenting and the trocar is delivered out along with the tracheostomy tube. The endotracheal tube is removed, and the tracheostomy tube is anchored in place.

Since these procedures involve an already intubated patient it calls for excellent coordination between the surgeon and the anaesthetist.

Routine pre operative ultrasound examination of the neck is a must because it will identify the site of an unusually large inferior thyroid veins which could cause troublesome bleeding during the procedure.

Contraindications:

1. A patient already in intense stridor.

2. Laryngeal malignancies

3. Short neck individuals

4. When proper trained personal are not available

5. Large thyoid gland

6. When ultrasound reveals an abnormally large inferior thryoid vein.

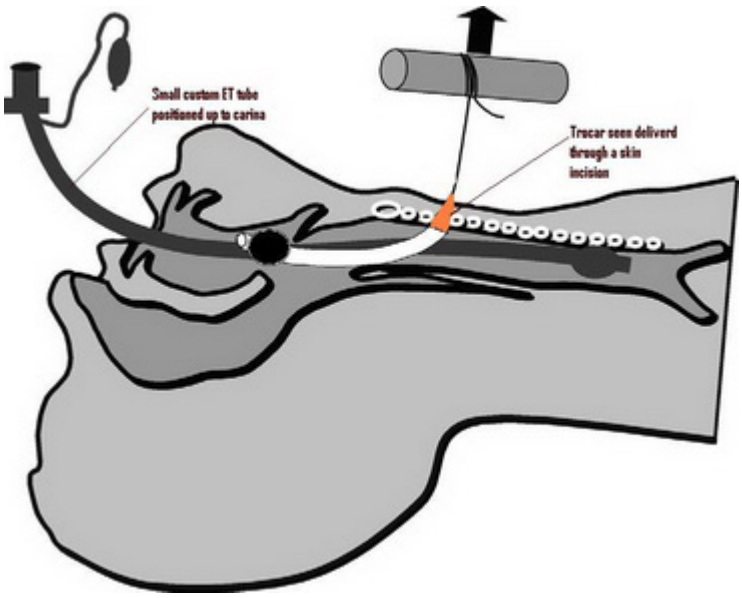


Diagram illustrating Fanconi Technique

Recurrent respiratory papillomatosis current concepts

Introduction:

Recurrent respiratory papillomatosis is a disorder of viral origin. It is associated with multiple exophytic lesions present in the airway. It is a benign disorder, but can cause airway complications with risk of malignant conversion. This disease is difficult to treat because of its tendency to recur. Some patients may experience spontaneous regression of the disease, while others may suffer from aggressive papillomatous growth requiring multiple surgical interventions. The reasons for this extremes in behaviour are not clearly understood.

Etiology: Human papilloma virus has been attributed as the causative organism. Viral particles have never been consistently demonstrated in the papilloma lesions even with electron microscopy. Use of viral probes have demonstrated papilloma virus DNA in all the papilloma lesions studied.

Human papilloma virus: is a small DNA containing non enveloped icosahedral (20 sided) capsid virus. The DNA is double stranded and circular.

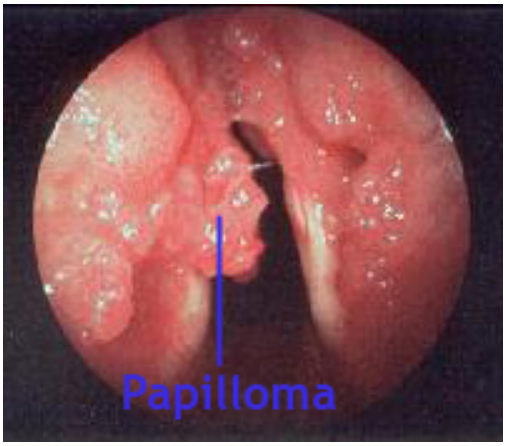


Figure showing papilloma of vocal folds

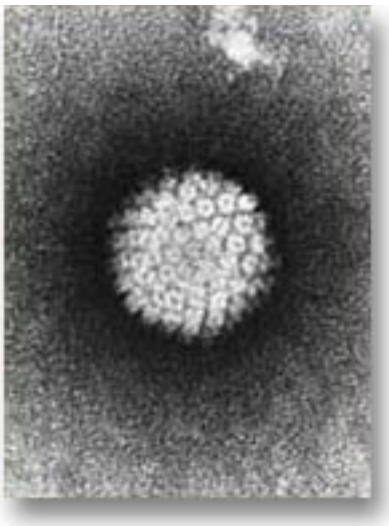


Figure showing papilloma virus

Depending on viral genetics 100 different types of human papilloma viruses have been identified. Among the types affecting the aerodigestive and genital tracts human papilloma virus types 6 and 11 have been associated with the lowest malignant potential, where as human papilloma virus types 16 and 18 have the greatest malignant potential. Children infected with human papilloma virus 11 have more obstructive airway early in the disease.

The human papilloma virus infects the basal layer of the mucosa. The viral DNA enters the cells and gets transcribed into RNA. This RNA is translated into viral proteins. After infection the viral DNA can either be actively expressed or can exist as latent infection in the mucosa. In latent infections the mucosa remains clinically and histologically normal. During latency, very little viral RNA is present inside the cells. Reactivation of the virus can occur at any time leading to symptoms.

The viral genome has 3 regions:

1. The upstream regulatory region

2. E region / Early region: The E genes are involved in oncogenes responsible for active replication of the viral genome.

3. L region / Late region genes encode viral structural proteins.

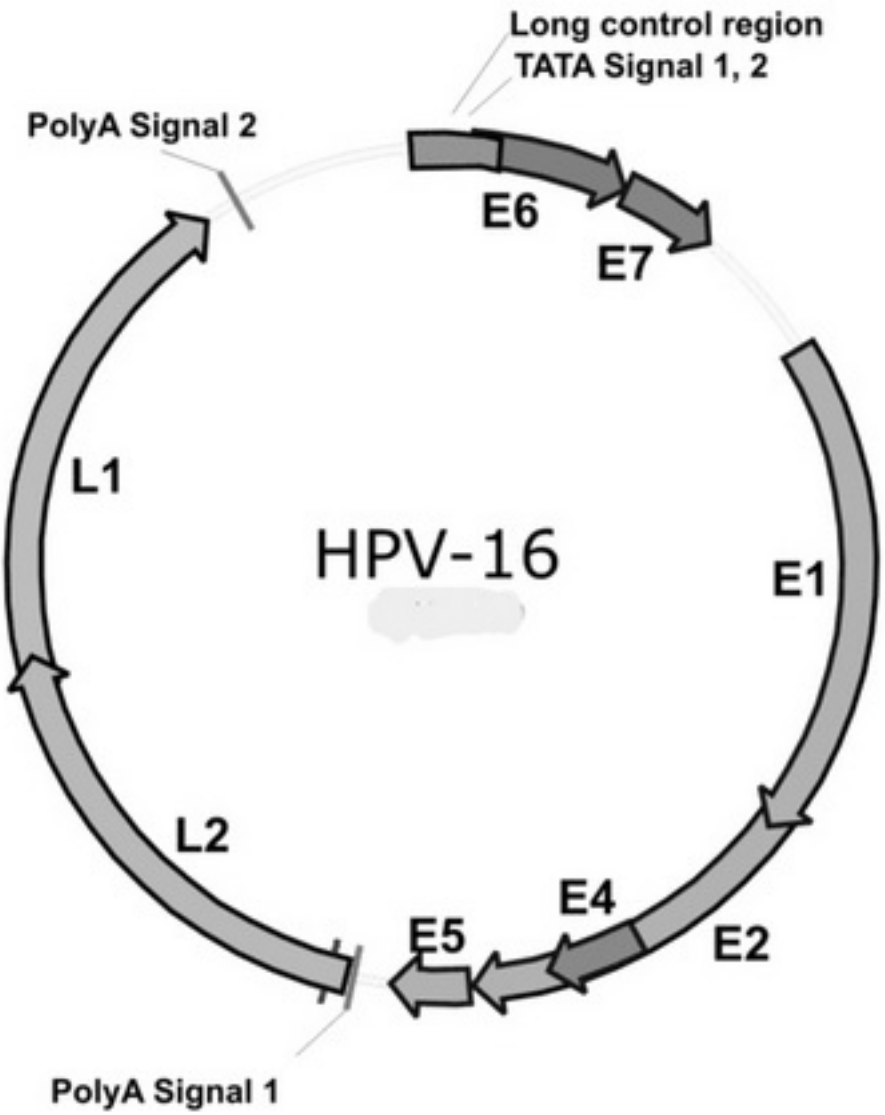


Figure showing ultrastructure of HPV

Human papilloma virus must have a means to reactivate the necessary host replication genes to facilitate its own DNA replication. One growth factor known to be associated with proliferation of epithelial cells is the epidermal growth factor receptor. Papilloma virus induce epithelial proliferation by increasing the level of expression of epidermal growth factor or its ligands. It may also increase cell proliferation by interacting with p53 or other tumor suppressor proteins inhibiting their normal functioning.

Host immune plays an important role in the pathogenesis of papilloma virus infections. The patient's immunocompetence may influence the clinical course of the disease. Both humoral and cellular immune responses may be compromised in children with recurrent respiratory papillomatosis.

Epidemiology:

Recurrent respiratory papillomatosis may have its clinical onset either during childhood or adulthood. Juvenile onset respiratory papilloma is more aggressive, and adult onset disease may be little bit less aggressive. In children recurrent respiratory papillomatosis is the most common benign neoplasm of the larynx.

Incidence may be very variable ranging from 2 - 3 / 100,000 population. Observations suggest that most of these patients are first born child to young primi gravida mothers. Primi gravida mothers are more prone for prolonged second stage of labor causing increased exposure to the virus. It is common in patients among low socioeconomic status. It is worthwhile to aggressively manage genital papillomatous infections to prevent vertical transmission of the infection from mother to child.

Transmission: The mode of transmission of human papilloma virus is unclear. Studies have demonstrated the link between childhood onset recurrent respiratory papillomatosis to mothers with genital papilloma virus infections; in adults evidence suggests that it could be associated with oro genital contact.

Histology: It appears as sessile or pedunculated masses. It may be pink or whitish in color. The masses consist of finger like projections of non keratinised stratified squamous epithelium supported by a core of highly vascularised connective tissue stroma. The basal layer may be either normal or hyperplastic and mitosis is generally limited to this layer.

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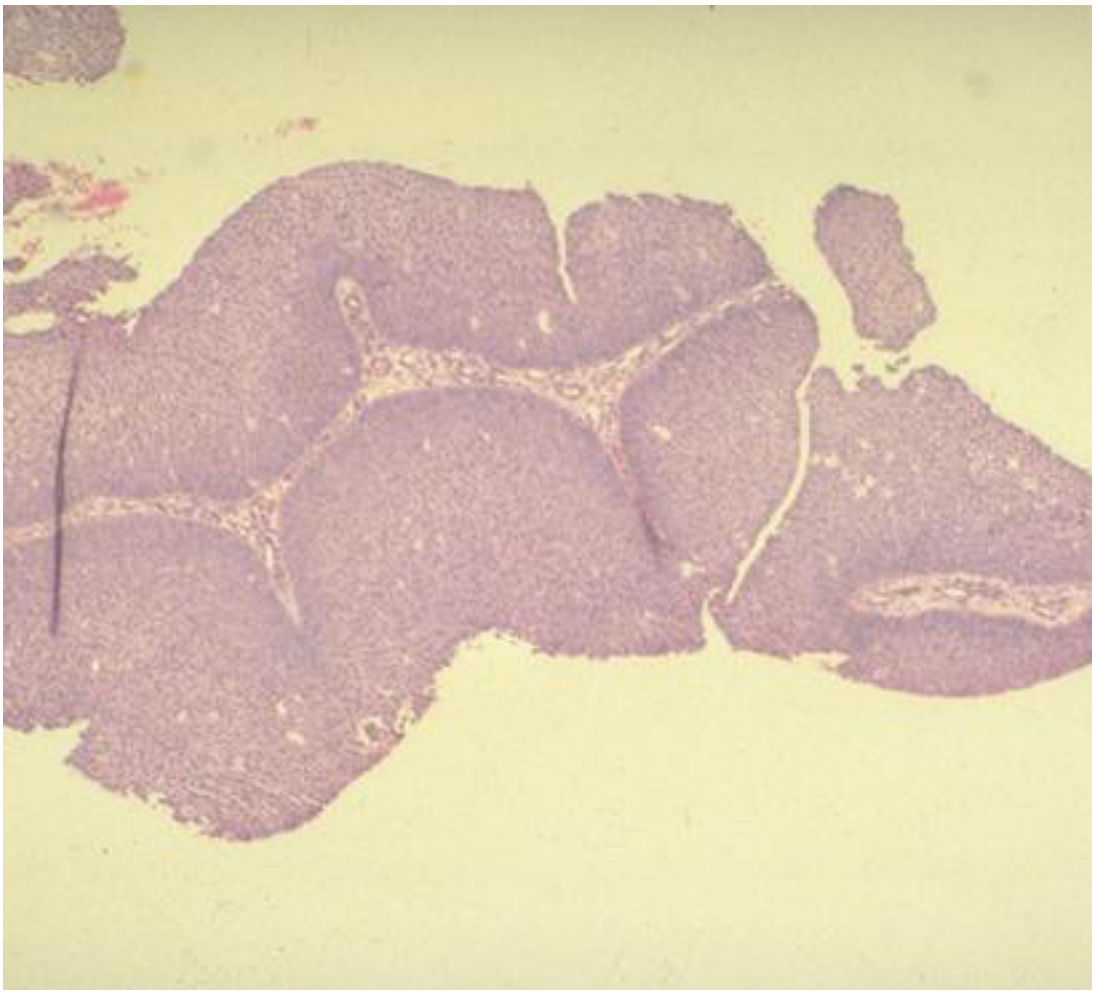


Figure showing Histology of respiratory papillomatosis

Recurrent respiratory papilloma lesions occur often at anatomic sites in which cilitated and squamous epithelium are juxtaposed. Common locations are:

1. Limen vestibuli of nose

2. Nasopharyngeal surface of soft palate

3. Laryngeal surface of epiglottis

4. Upper and lower margins of ventricle

5. Under surface of vocal folds

6. Carina

7. Bronchial spurs

Areas of transition from ciliated respiratory eithelium to native or metaplastic squamous epithelium are commonly involved as seen in patients with tracheostomies. Papilloma is seen at the stoma and in the mid thoracic trachea. Children with broncho pulmonary dysplasia, in whom prolonged endotracheal intubation may result interruption of the continous respiratory mucosal surface causing increased incidence of respiratory papillomatosis.

Injury to respiratory mucosa caused by prolonged gastro oesophageal reflux may also increase the risk of respiratory papillomatosis. Iatrogenic implantation of papilloma may be prevented by avoiding injury to non diseased squamous or ciliated epithelium adjacent to areas of frank papilloma.

Clinical presentation:

Hoarseness: of voice may occur depending on the position of the papilloma. It is worse if the lesion is present in the vocal cord.

Stridor: occurs if the mass occludes the laryngeal inlet. Commonly inspiratory becoming biphasic later.

Dysphonia: Children with respiratory papillomatosis always present with certain degree of dysphonia

Physical examination:

Affected children should undergo complete physical examination. Airway compromise if any must be given top priority. Tracheostomy will have to be performed in cases of acute airway obstruction. Definitive diagnosis is possible only after flexible fibre optic bronchoscopic examination.

Coltera and Derkay have evolved a staging system to stage recurrent papillomatous lesions involving the respiratory tract.

Coltera-Derkay method of staging :

Clinical score:

1. Voice: Normal - 0, Abnormal - 1, Aphonia - 2

2. Stridor: Absent - 0, Present on activity - 1, Present at rest - 2

3. Respiratory distress - None - 0, Mild - 1, Moderate - 2, Severe - 3, Extreme - 4.

Anatomical score:

For each site - 0 = none, 1=surface lesion, 2= raised lesion, 3=bulky lesion.

Total score = Anatomical score + Total clinical score

Management:

Surgical: Microlaryngeal excision of the lesion is performed. Laser excision is preferred in recurrent cases, and for cases where tracheal mucosa is involved.

Adjuvant treatment: Most commonly adopted criteria for initiating adjuvant therapy is the requirement of more than 4 surgical procedures during a calender year, distal multispread of disease.

Cidofovir: is a nucleoside analog that has antiviral activity against herpes family of virus. This drug has been shown to induce apoptosis in human papilloma virus infected cells.

Interferons: are manufactured by cells in response to a variety of stimuli, including viral infection. Interferons when administered produce a blocking effect on viral replication of RNA and DNA. It also alters the cell membrane causing it become impervious to viral penetration. Hence interferon can be adminstered as adjuvant.

Side effects of interferons include:

1. Flu like symptoms

2. Decreased growth rate of child

3. Leukopenia

4. Spastic diplegia

5. Thrombocytopenia

6. Alopecia

7. Pruritus

8. Fatigue

Photodynamic therapy:

Is based on the transfer of energy to a photosensitive drug. The drug used is dihematoporphyrin ether (DHE). This drug has a tendency to concentrate within papillomas more than in surrounding normal tissue. Patients are typically treated intravenously with 4.25mg /kg of DHE before photoactivation with an argon pump dye laser.

Ribavirin: is an antiviral drug used to treat pneumonia in infants caused by respiratory syncytial virus has shown some promise in the treatment of aggressive papillomatosis.

Sulcus vocalis and its management

Synonyms: Vocal fold cleft, vocal fold scarring.

Definition: Sulcus vocalis is caused by migration of the vocal fold epithelium in to the normally convex lamina propria, causing a cleft in the vocal fold. The presence of this cleft alters the way vocal folds osscilate causing voice changes.

Classification of sulcus vocalis: Ford etal classified sulcus vocalis into three types: In all these types the cleft is present on the medial surface of the vocal fold.
Ford Type I: Here the longitudinal depression of the vocal fold epithelium extends into the lamina propria, but does not reach the vocal ligament. This depression extends often along the full length of the vocal cord. This sulcus is commonly present and cause only a mild vocal dysfunction. Hence it is often termed as physiologic sulcus.

Ford Type II: The sulcus extends throughout the full length of the vocal cord. The depression extends upto the vocal ligament, there is also an associated loss of lamina propria. This anamoly causes a disruption of the mucosal wave pattern which is responsible for normal voice production.

Ford Type III: Here the sulcus is deep and focal in nature giving the apprearance of a pit. The whole length of the cord is not involved. There is also an associated loss of lamina propria. This type of defect causes a disruption of the mucosal wave. Histology of these lesions show diffuse fibrosis, neovascularisation and inflammation.

Image showing Sulcus Vocalis

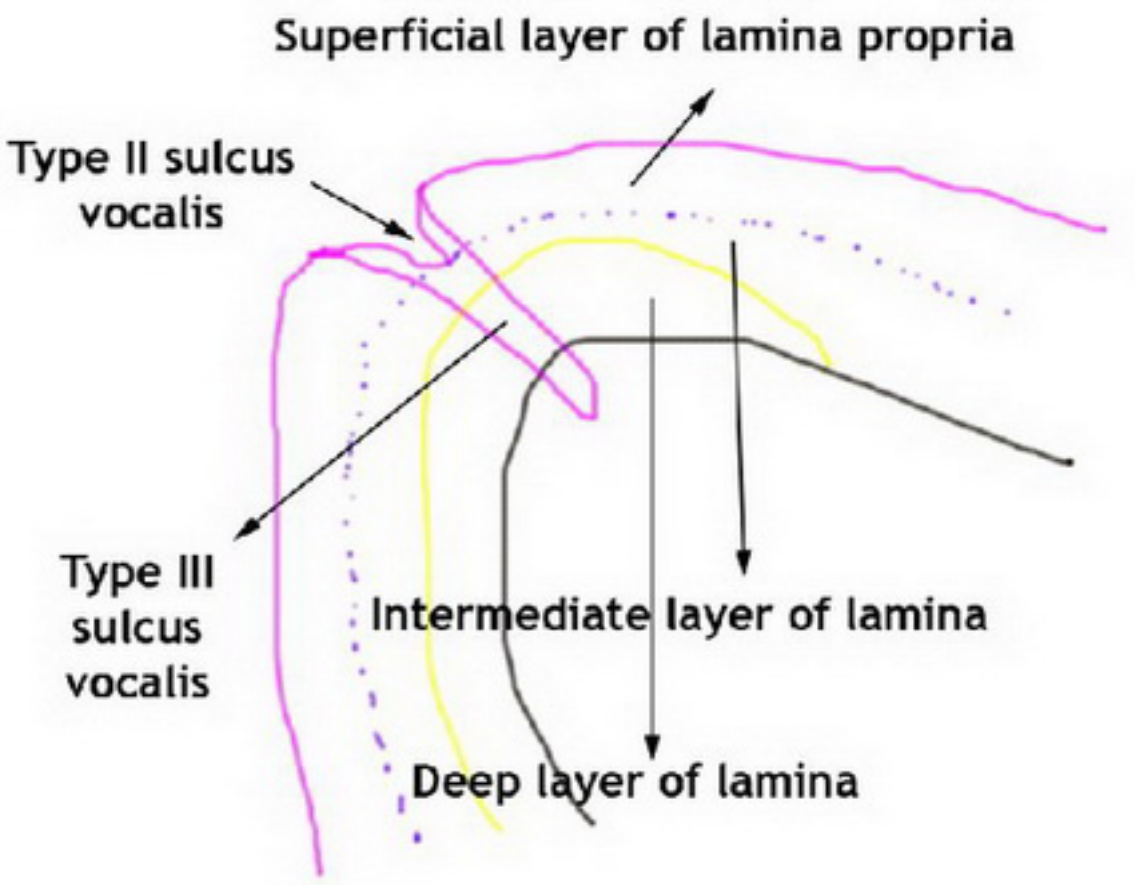

Superficial layer of lamina propria
Type II sulcus vocalis
Type III sulcus vocalis
Intermediate layer of lamina
Deep layer of lamina

Figure showing types of sulcus vocalis

Etiopathogenesis of sulcus vocalis (Theories): As usual congenital and acquired theories have been postulated to explain the etiopathogenesis of sulcus vocalis.

Arnold Bouchayer theory: This theory attributes a congenital cause to explain the etiopathogenesis of sulcus vocalis. This theory postulates a faulty genesis of the 4th and 6th branchial arches as the cause for sulcus vocalis. Epidermoid cysts present in the vocal fold due to this faulty genesis of 4th and 6th arches are believed to rupture causing this disorder. Genetically, in these patinets vocal fold scars are characterised by replacement of the normal micro architecture by disorganised collagen causing a reduction in the volume of vocal fold thus making it less pliable to vibrations during speech.
The following factors favour this theory:

1. Appearance in childhood.

2. Not known to recur after surgery.

3. Familial propensity.

Microscopically these lesions are characterised by the presence of:

1. Fibrosis

2. Neovascularisation

3. Inflammation

Van Canegham's theory: attributes this condition to be acquired in nature. Trauma and mycobaterial infections have been implicated as probable causes for this condition. In fact a significant amount of sulcus vocalis has been found in the opposite vocal cord when the ipsilateral vocal cord is affected by malignant lesion. This lends credence to this theory.

Recent authors have accepted both these theories as probable cause of sulcus vocalis.

Clinical features: Patients will complain of chronic hoarseness of voice, vocal insufficiency and loss of quality of voice. Indirect laryngoscopy and direct laryngoscopic examinations will demonstrate the presence of sulcus vocalis in the free margin of the vocal folds. On video stroboscopy loss of mucosal wave in the affected portions of the vocal folds will be clearly appreciated.

Management: The goal in managing this problem is to improve the glottic efficiency, reduce strain to the vocal folds, and improvement in the overall voice quality.

1. Patient must be advised adequate voice rest.

2. Speech therapy and speech councelling should be attempted.

3. GERD if present must be aggressively treated.

4. Rhinosinusitis if present must be treated

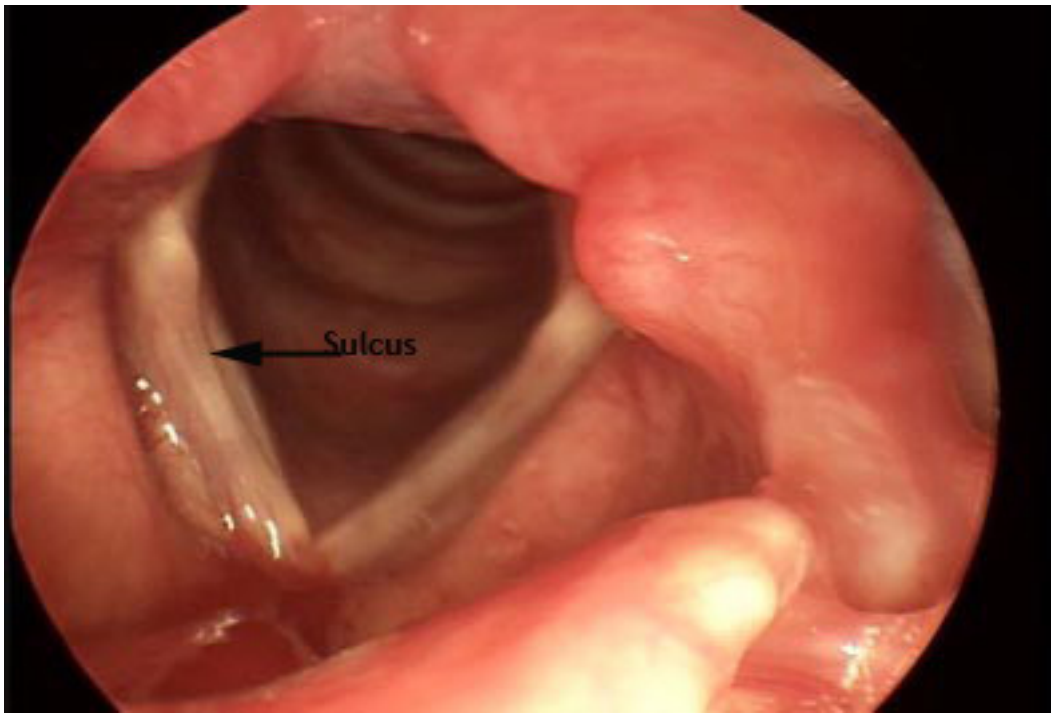


Image showing sulcus vocalis

Surgical management:

Multiple surgical techniques have been formulated for treatment of sulcus vocalis. Before prceeding with surgical management one aspect should be clearly assessed: the ability of the surgeon to visualise the full length of the vocal cord endoscopically. If such clear visualisation is not possible then medialisation thyroplasty or injection thyroplasty or voice therapy may be resorted to.

Medialisation thyroplasty:

This technique is used to close the glottic gaps commonly seen in sulcus vocalis. This procedure cannot be performed endoscopically. This is an external procedure which uses different medialising implants like silastic, Gore-tex or hydroxyapatite blocks. Sometimes strap muscles can also be used is autogenous graft is preferred. Goretex is the preferred material to medialise the vocal fold. This material not only reduces the glottic gap it also maintains the normal pliability of the vocal folds. The surgical procedure will be detailed elsewhere.

Collagen injection:
Collagen can be injected into the vocal fold thereby causing medialisation of the injected vocal fold. This procedure can be preformed through an endoscopic approach. This injection can be performed under out patient settings. This injection closes the glottic gap causing an improvement in the quality of voice. The only problem with this method is that collagen has been known to be absorbed by tissues. No long term study is available to study the long term effects of this injection. Large gaps cannot be treated by this method.

Cold redrape: This procedure is performed under microlaryngeal approach. It involves a longitudinal epithelial cordotomy with release of the sulcus from its depth followed by simple redraping of the epithelium. The major advantage of this procedure is that implants need not be used and is a fairly simple procedure to perform. The release of the tethered tissue helps to close the glottic chink somewhat better. One major word of caution is that the healing process of the epithelial cover is not under our control, ultimately the operated area may heal with fibrosis reducing the pliability of the vocal fold whereby worsening the condition. Surgery must hence be performed with utmost caution with minimal trauma to the covering mucosa.

Laser undermining with redraping: CO2 laser is used lto perform the cordotomy. It has the advantage of excellent hemostasis with minimal trauma to the surrounding tissues. Steroids are injected at the time of redraping and fibrin glue is applied to the epithelium to facilitate reapproximation and tissue healing of the epithelial cover.

Slicing technique of Pontes and Behlau: This technique utilises the principles of scar contracture repair. The scar bands are interrupted with medial advancem ent of vocal fold cover. In this procedure cuts of varying lengths are made in the coronal plane of the vocal fold to release the longitudinal scar band. This procedure is reserved for cases of severe deformities where less aggressive surgical management may not suffice.

Fat injection: Glottic insufficiencies can be corrected by injecting fat into the paraglottic space. This can be achieved via a laryngofissure approach.

Endoscopic Dacryocystorhinostomy

History: Endonasal approach to correct nasolacrimal obstruction was described way back in 1800 by Caldwell, West and later during the begining of 1900 by Mosher. This approach was not popular because of technical limitations which included visualisation and availability of instruments for soft tissue and bone removal. Toti popularised external dacryocystorhinostomy, and this procedure was in vogue for quite sometime. The introduction of rigid nasal endoscopies kindled interest in the endo nasal approach to the lacrimal sac.
The first dacryocystectomy was performed by Celsus in 50 AD. McDonogh was the first to perform endoscopic dacryocystorhinostomy in 1989.

Anatomy of lacrimal apparatus:
Knowledge of lacrimal apparatus is a must before embarking on endonasal lacrimal sac surgery. The lacrimal system consists of a superior and inferior puncta at the medial ends of upper and lower eyelids. These two drain into upper and lower canaliculi. These two canaliculi join to form the common canaliculus. This zone is known as the upper lacrimal system. The common canaliculus inturn leads into the lacrimal sac. The sac is about 12 - 15 mm long. It eventually narrows and leads into the nasolacrimal duct which drains into the inferior meatus of the nose. The naso lacrimal duct is about 18 mm long. The sac and the duct comprise the lower lacrimal system.
The junction between the common canaliculus and the lacrimal sac is guarded by the Rosenmuller valve. This valve prevents tear reflux.

The nasal end of the nasolacrimal duct at the level of inferior meatus is guarded by Hasner's valve.

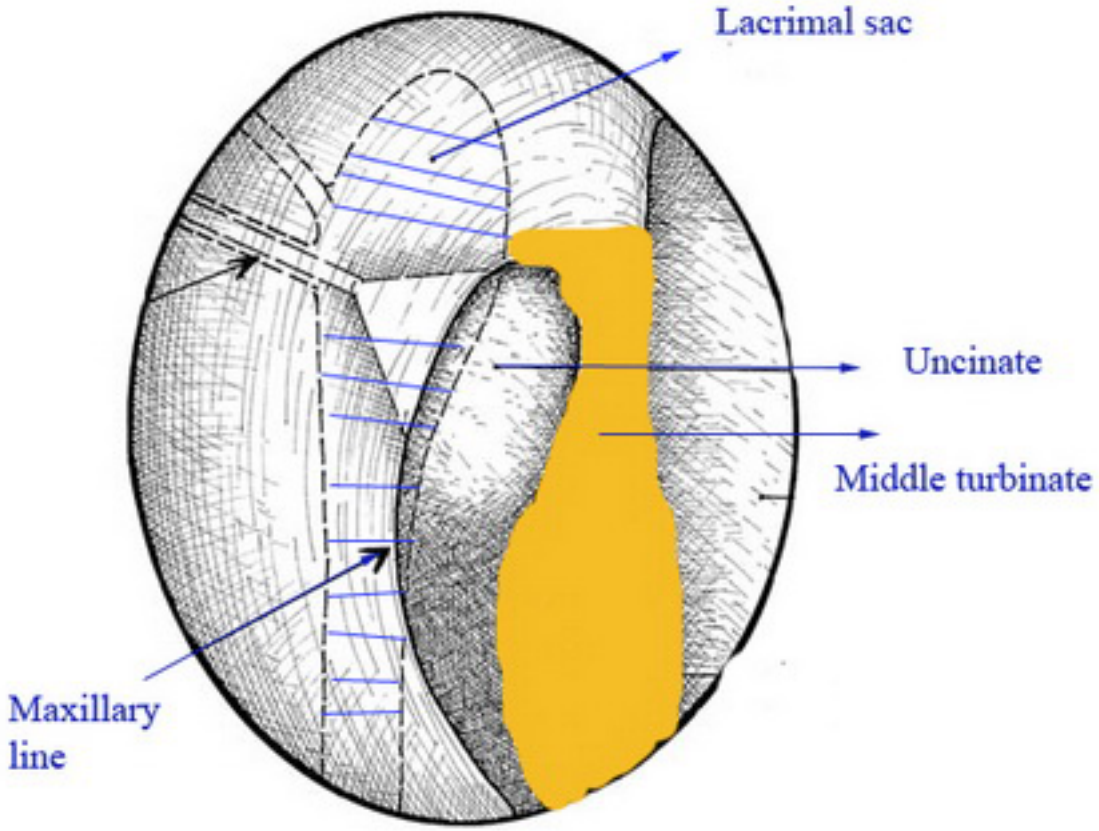
Physiology of lacrimal apparatus: Tears move from the eye into the nose through a mechanism known as the lacrimal pump. Movements of the lids cause the puncta to close against each other, pushing tears into the lacrimal sac. Tears accumulating in the sac (lacrimal lake) are further pushed down into the nasolacrimal duct when the eyes open because of the relative negative pressure caused in the lacrimal lake.

Location of lacrimal sac: A good intranasal landmark for the location of lacrimal sac is the anterior portion of middle turbinate, the sac lies just lateral to it. The lacrimal fossa is bounded by the anterior lacrimal crest, which consists of the frontal process of the maxillary bone. The posterior lacrimal crest is made up of the lacrimal bone itself.

The maxillary line is a mucosal projection along the lateral nasal wall that serves as a landmark for endoscopic sinus and orbital procedures.

Indications for Primay endoscopic dacryocystorhinostomy:

1. In the management of tearing associated with primay acquired nasolacrimal duct obstruction
2. Infection of lacrimal sac associated with primary acquired nasolacrimal duct obstruction
3. Nasolacrimal duct obstruction secondary to specific inflammatory or infiltrativer disorders
4. The level of obstruction should be distal to the junctionof the lacrimal sac and the duct.
5. In the management of lacrimal duct injuries associated with sinus surgeries



Intranasal landmark of lacrimal sac

Contraindications of endoscopic DCR:

1. Presence of a firm indurated mass above the level of medial canthus.
2. Bloody epiphora
3. Presence of bony destruction as seen in radiological films
4. Pseudoepiphora: is essentially reflux tearing: the main gland over compensates secretion because of lack of secretion from minor glands of along the lid margin.

History & patient examination:

1. History of unilateral or bilateral tearing must be sought. Unilateral tearing mostly indicates obstructive pathology.
2. Nature of the discharge must also be sought i.e. whether clear or purulent
3. Environmental factors, such as allergies should be elicited. Medication histories are important as well as previous history of trauma or surgery.
4. On physical examination - palpate the region of the nasolacrimal sac to see if you can elicit any reflex from the puncta.
5. Eyelids should be carefully examined for evidence of excessive laxity, punctum should be examined for evidence of obstruction or inflammation. Excessively lax eyelids could cause epiphora. DCR may not help these patients
6. The canaliculi must be probed using a Biwman probe. A hard obstruction could be caused by bone or calculi, a soft obstruction could be caused by obstruction by soft tissue. Nasolacrimal duct can be further examined by irrigating the duct with a syringe.
7. Jones test should be performed to identify the level of obstruction:

Jones test: The Jones test is a test of the patency of the nasolacrimal system. The test is performed by placing fluorescein in the conjunctival sac and seeing whether or not this fluorescein can be visualized in the nose. If after a period of five minutes there is impaired outflow, it is likely that there is an obstruction somewhere in the duct or somewhere in the system. If you do not see any dye in the nose after five minutes, then you can perform a secondary test, by irrigating the duct. If after irrigating the duct no dye is found in the nose, the dye has never really reached the lacrimal sac to begin with. The obstruction is likely proximal. If you do see dye in your irrigate, then dye did reach the nasolacrimal sac, and it is likely that your obstruction is distal.

CT scan of paranasal sinuses should be taken to identify the cause of nasolacrimal duct obstruction.

Surgical procedure:

Anaesthesia: This surgery can be performed either by using General or local anaesthesia. If general anesthesia is preferred, the nasal mucosa should be decongested by placement of cotton pledgets dipped in 0.05% oxymetazoline in the middle meatus, this is followed by an injection guided endscopically of 1% xylocaine with 1:200,000 epinephrine into the lateral nasal wall and middle turbinate. If local anaesthesia is preferred, topical anaesthesia is achieved by the use of pledgets dipped in 4% xylocaine mixed with 1:200,000 adrenaline to pack the nasal cavity. 1% xylocaine with 1:200,000 adrenaline is used to infiltrate the lateral nasal wall and middle turbinate for adequate anesthesia.

Localisation of lacrimal sac: The sac must be identified endsocopically. A guide to its position is the insertion of the root of the middle turbinate on the lateral nasal wall and the maxillary line. In patients with distorted nasal anatomy following previous nasal surgeries the use of fibreoptic endoilluminator can be resorted to. This 20 guage illuminator is advanced gently through the superior or inferior canaliculus until a hard stop occurs signifying the lacrimal bone medial to the lacrimal sac is identified. The location of the sac can now be visualised endoscopically.

Mucosal incision: After localising the position of the sac endoscopically, the lateral wall mucosa is incised with a sickle knife and is elevated using a Freer elevator. It will be of immence help if this incision could be placed well anterior to the location of the sac as this will allow adequate exposure of bone. The incision is made vertically from inferior to superior. After elevation the mucosa is removed using a Blakesley forceps.

Bone removal: To expose the lacrimal sac, the bony lacrimal fossa must be uncovered first. The endoilluminator if used will greatly help in identifying the position of the sac. Bone removal can be performed using a Kerrison's punch forceps or by using a motor and burr. The bone removal should commence from the maxillay line and should proceed anteriorly.

Opening of lacrimal sac: After overlying bone removal the lacrimal sac can be incised using a sickle knife. It will be helpful if an assistant could tent out the medial wall of the sac with lacrimal probes introduced through the canaliculi. The whole of the medial wall of the sac is removed.
Topical mitomycin can be applied to the site of surgery to prevent restenosis of the sac.

Advantages of endoscopic dcr:

1. There is no external scar.
2. The lacrimal pump system is preserved.
3. Any concomittant intranasal pathology causing epiphora can be addressed
4. Lacrimal sac mucosa is preserved

Voice Rehabilitation following Total Laryngectomy

Introduction:

The current 5 year survival rate of patients following laryngectomy ranges between 75-80% . Larynx is the second commonest site for cancer in the whole of aero digestive tract. Commonest malignancy affecting larynx is squamous cell carcinoma. Surgery carries a good prognosis. Conservative laryngeal surgeries are getting common by the day. After total laryngectomy there is a profound alteration in the life style of a patient. The patient is unable to swallow normally, associated with profound changes in the pattern of respiration. Olfaction is also affected. The importance of speech is not appreciated unless it is lost.

Physiology of phonation:

Voice is produced by the respiratory system with active lungs forming the bellows pumping air into the laryngeal cavity. Vibrating air in the larynx generates voice. Clear and understandable speech is created by articulators (lips, tongue, teeth etc.). The larynx acts as a transducer during phonation converting the aerodynamic forces generated by the lungs, diaphragm, chest and abdominal muscles into acoustic energy. This energy transduction precisely at the space between the two vocal folds. However subglottic and supra glottic pressures also play a role in this transformation of aerodynamic energy into sound energy.

The requirements of normal phonation are as follows:

1. Active respiratory support
2. Adequate glottic closure
3. Normal mucosal covering of the vocal cord
4. Adequate control of vocal fold length and tension.

The vibrations of the vocal folds are complex in nature and are known as the glottic cycle. This cycle involves glottic opening and closing at set frequencies determined by the subglottic air pressure. Normal vocal folds produce three typical vibratory patterns:

1. Falsetto
2. Modal voice
3. Glottal fry

In falsetto or (light voice) the glottic closure is not complete, and only the upper edge of the vocal fold vibrates.

In Modal voice complete glottic closure occurs. This occurs in a majority of mid frequency range voice. During this modal voice production the vocal fold mucosa vibrates independently from the underlying vocalis muscle. This is the basic frequency at which a person phonates. The modal frequency in adult males is 120 Hz while in adult females it is 200 Hz.

Glottal fry is also known as low frequency phonation is characterized by closed phase. This closed phase is long when compared to the open phase. The vocal cord mucosa and vocalis muscle vibrate in unison. During phonation two vibratory phases occur i.e. open and closed phases. The open phase denotes the phase during which the glottis is at least partially open, while the closed phase denotes the phase when the vocal folds completely occlude the glottic chink.

The open phase can be further divided into opening and closing phases. The opening phase is defined as the phase during which the vocal folds move away from one another, while during the closing phase the vocal folds move together in unison.

One important physiologic parameter which must be noted during phonation is the mucosal wave. The mucosal wave is an undulation which occur over the vocal fold mucosa. This wave travels in an infero superior direction. The speed of mucosal wave ranges from 0.5 - 1 m/sec. The symmetry of these mucosal waves must also be taken into consideration while studying the physiology of voice production. Any mild asymmetry between the two vocal folds must be considered as pathological.

The function of vocal folds is to produce sound varying in intensity and pitch. This sound is then modified by various resonating chambers present above and below the larynx and are converted into words by the articulating action of the pharynx, tongue, palate, teeth and lips.

The consonants of speech can be associated with particular anatomical sites responsible for their generation i.e. 'p' and 'b' are labials,'t' and'd' are dentals and 'm' and 'n' are nasals.

Methods of alaryngeal speech:

There are 3 methods of alaryngeal speech. They include:

1. Oesophageal speech
2. Electrolarynx
3. Tracheo oesophageal puncture

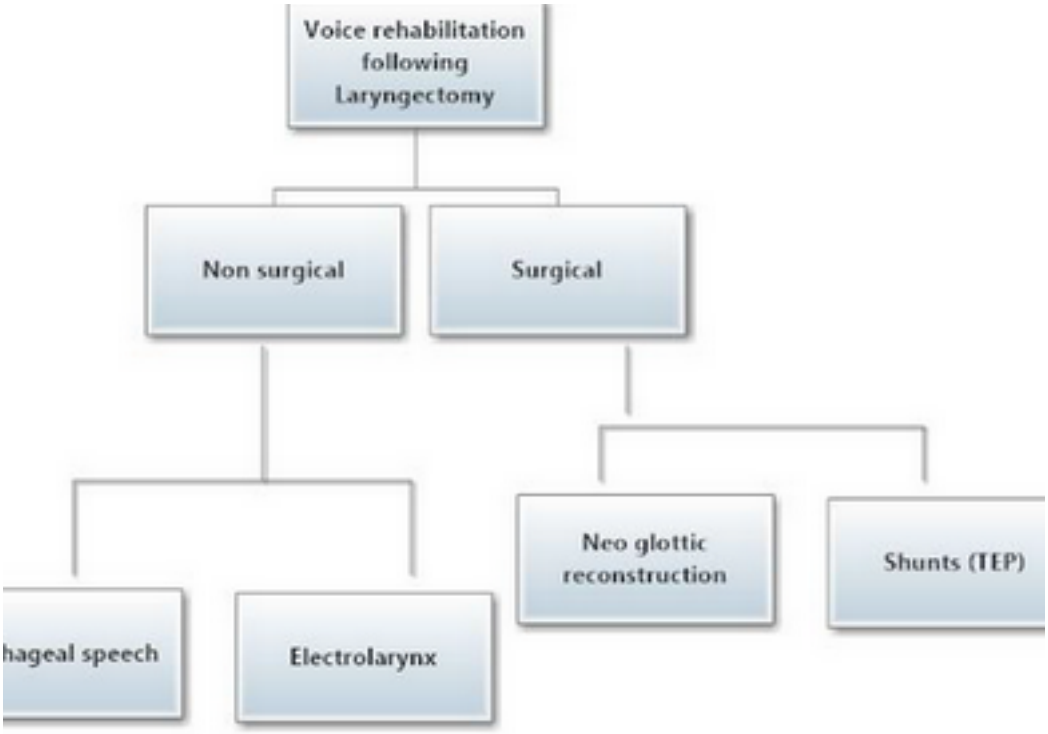
Oesophageal speech: Patients after total laryngectomy acquire a certain degree of oesophageal speech. In fact all the other alaryngeal speech modalities are compared with that of oesophageal speech. It is the gold standard for post laryngectomy speech rehabilitation methods during 1970's. In this method air is swallowed into the cervical esophagus. This swallowed air is immediately expelled out causing vibrations of pharyngeal mucosa. These mucosal vibrations along with tongue in the oral cavity cause articulations. The exact vibrating portion in these patients is the pharyngo esophageal segment. This segment is made up of musculature and mucosa of lower cervical area (C5 – C7 segments). This method is very difficult to learn and only 20 % of patients succeed in this endeavor.
Patients with oesophageal speech speak in short bursts, as the bellow effect of the lungs are not utilized in speech generation. The vibrations of muscles and mucosa of cervical esophagus and hypopharynx are responsible for speech production. Oral cavity plays an important role in generation of oesophageal speech. Air from the oral cavity is swallowed into the cervical oesophagus before speech is generated.

There are two methods by which air can be pumped into the cervical oesophagus.
They are:

Injection method: In this method the person builds up enough positive pressure in the oral cavity forcing air into the cervical oesophagus. This is achieved by elevating the tongue against the palate. Air can also be injected into the cervical oesophagus by voluntary swallowing. Lip closure along with elevation of tongue against the palate generates enough positive pressure within the oral cavity to force air into the cervical oesophagus. This method is also known as tongue pumping, glossopharyngeal press and glossopharyngeal closure. This method is effective before speaking Obstruent phonemes like plosives, fricatives and affricatives.

Inhalational method: This method uses the negative pressure used in normal breathing to allow air to enter the cervical oesophagus. The air pressure in the cervical oesophagus below the cricopharyngeal sphincter has the same negative pressure as air in the thoracic cavity. Hence during inspiration, this pressure falls below atmospheric pressure. Laryngectomees often learn to relax the cricopharyngeal sphincter during inspiration thereby allowing air to get into the cervical oesophagus as it enters the lung. This trapped cervical column of air is responsible for speech generation. Patients are encouraged to consume carbonated drinks during the initial phases of rehabilitation. Gases released can be expelled into the cervical oesophagus causing speech generation.

The major advantage of oesophageal speech is that the patient's hands are free. The patient does not have to incur cost of a surgical procedure or a speaking device. Nearly 40% of patients fail to acquire oesophageal speech even after prolonged training. This could be due to cricopharyngeal spasm / reflux oesophagitis. Reflux must be aggressively treated. Cricopharyngeal myotomy must be performed in patients with cricopharyngeal spasm. Botulinum toxin injection into the cricopharyngeus muscle can also be attempted 30 Units of Botulinum toxin is injected via anterior portion of the neck (via the tracheostome over the posterior pharyngeal wall bulge.



Flow chart showing various voice restoration options following laryngectomy

Common cause of failure to develop oesophageal voice:
1. Presence of cricopharyngeal spasm
2. Disorders involving pharyngo oesophageal segment
3. Poor motivation on the part of the patient

Cricopharyngeal spasm can be managed by performing cricopharyngeal myotomy on a routine basis in all patients undergoing total laryngectomy. If this fails Botulinum toxin injection can be resorted to.

Advantages of oesophageal speech:

1. Hands free speech
2. No additional equipment is necessary
3. No additional surgery is necessary

Disadvantages of oesophageal speech:

1. Significant training is necessary
2. Controlling pitch and loudness can be really difficult in these patients
3. The fundamental frequency of oesophageal speech is about 65 Hz which is about half of the normal adult male speaker. Its intensity is also pretty low making it difficult for the speaker to he understood in noisy environments.

Electrolarynx: These are vibrating devices. A vibrating electrical larynx is held in the submandibular region. Muscular contraction and facial tension can be modified to generate rudiments of speech. The initial training phase to use this machine must begin even before the surgical removal of larynx. This helps the patient in easy acclimatization after surgery.

There are three types of electro larynges available. They are:

1. Pneumatic - Dutch speech aid, Tokyo artificial speech aid etc.
2. Neck
3. Intra oral type

Among these three types neck type is commonly used. It should be optimally placed over the neck for speech generation. Hypoesthesia of neck during early phases of post op period may cause some difficulties in proper placement of this type of artificial larynx. If this device cannot be used intra oral devices can be made use of.

While using intra oral type cup must form a tight seal over the stoma so that air does not escape during exhalation. The oral tip of the tube is positioned in the oral cavity. The pneumatic artificial larynx uses the patient's exhaled air to create the fundamental sound. A rubber, plastic, or steel cup is placed over the stoma, creating a seal. A tube is then directed from the cup into the mouth.

The exhaled air vibrates a reed or rubber diaphragm within the cup, creating a sound. Speech quality can be varied through a number of mechanisms. Changes in breath pressure can affect pitch and loudness.

Figure showing Electrolarynx

The major disadvantage of these electro laryngees is their mechanical quality of speech. There is also a certain degree of stomal noise. With practice a patient can reduce stomal noise by placing fingers over the stoma during phonation. These equipment are expensive and need to be maintained.

Voice restoration surgeries in patients who have undergone Laryngectomy:

1. Neoglottic reconstruction
2. Shunt techniques

Neoglottic reconstruction:
Numerous surgeons all over the world attempted to develop a reliable tracheohyoidpexy procedure which could restore voice function in patients who has undergone Total Laryngectomy. Most of these techniques were abandoned due to complications.

Advantages of Electrolarynx:

1. Can be easily learnt

2. Immediate communication is possible

3. Additional surgery is avoided

4. These devices can be used even attempting to master oesophageal speech / TEP speech.

Disadvantages of Electrolarynx:

1. Voice generated is metallic in natiure

2. This device needs use of hand and hence cannot be used hands free

3. Difficult while speaking over phone

4. Regular battery change is needed

Shunt technique:

This technique involves creation of shunt between trachea and oesophagus. This technique was first developed by Guttmann in 1930. Lots of modifications have occurred, but the basic concept remains the same. Basic aim of this procedure is to divert air from the trachea into oesophagus. The place where sound is generated depends on where the fistula enters pharynx / oesophagus.

Types of shunts:

1. High Tracheo-oesophageal shunt (Barton)

2. Low Tracheo-oesophageal shunt (Stafferi)

3. TEP shunts (GUTTMANN)

Creation of shunt between trachea and oesophagus usually failed because:

1. Aspiration through the fistula

2. Closure of fistula

This lead to the development of one way voice prosthesis designed by Blom and Singer which was introduced via the puncture wound.

Voice Prosthesis

Indwelling

Non indwelling

Prosthesis should be introduced by Medical Professional

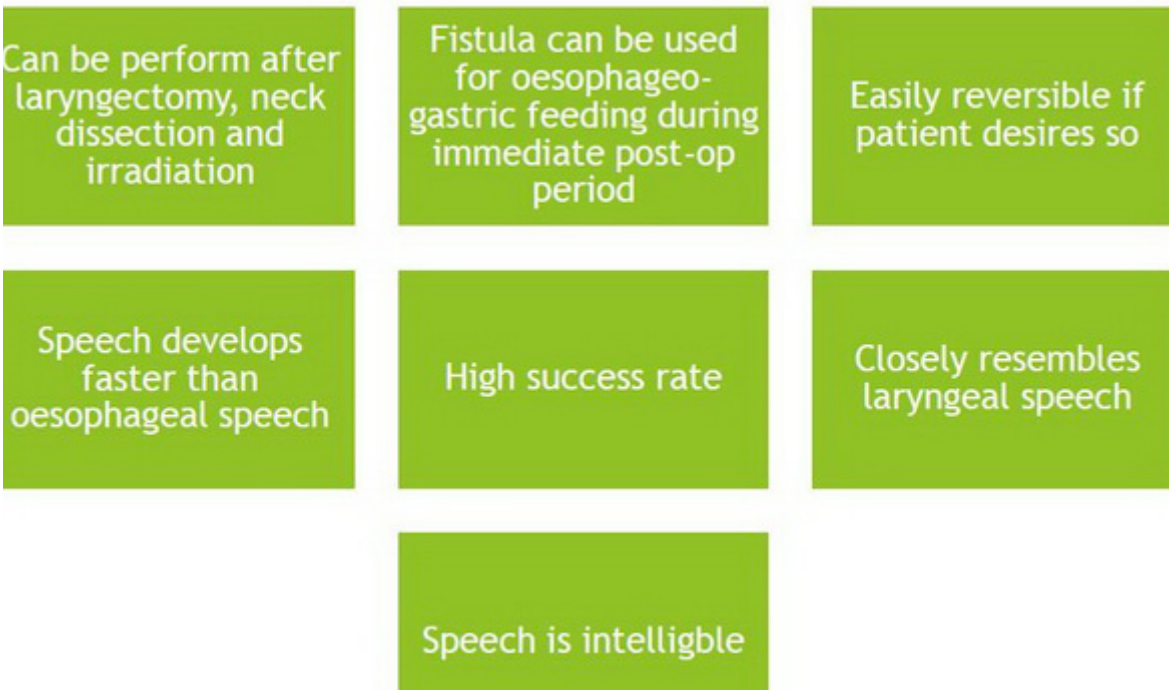
Device placement can be done by the patient

Tracheo esophageal puncture (TEP):

This procedure for restoration of speech in patients who have undergone total laryngectomy was first introduced by Blom and Singer in 1979 . In addition to the procedure of tracheo oesophageal puncture Blom – Singer developed a silicone one way slit valve which can be inserted into the puncture wound. This valve formed a one way conduit for air into the oesophagus and also prevented leakage of oesophageal contents into the airway. Voice prosthesis is actually a one way valve made of medical grade silicon. This is a barrel shaped device with two flanges. One flange enters the oesophagus while the other one rests in the trachea. It actually fits snuggly into the tracheo-oesophageal puncture wound. This prosthesis is provided with a unidirectional valve at its oesophageal end. Indwelling prosthesis usually have more larger and rigid flanges when compared to that of non-indwelling ones. Non-indwelling prosthesis has a safety medallion attached to the main structure to prevent accidental aspiration.
TEP can be performed either immediately after laryngectomy or 6 weeks following successful laryngectomy. TEP performed along with laryngectomy is known as Primary TEP and if performed weeks after laryngectomy it is known as Secondary TEP. It should be stressed that radiotherapy poses no threat to TEP. This procedure initially was reserved for patients who have failed to acquire oesophageal speech even after prolonged effort, and are displeased with the voice produced by artificial larynx. Currently Primary TEP is getting popular.

Anatomical structures involved in TEP:

TEP should ideally be performed in the midline, thereby decreasing the risk of bleeding from midline vessels. Structures that need to be penetrated during TEP procedure include:
1. Membranous posterior wall of trachea
2. Oesophagus (Consists of 3 muscles layers coated with oesophageal mucosa)
3. Interconnecting tissue in the tracheo-oesophageal space


Can be perform after laryngectomy, neck dissection and irradiation
Fistula can be used for oesophageo-gastric feeding during immediate post-op period
Easily reversible if patient desires so
Speech develops faster than oesophageal speech
High success rate
Closely resembles laryngeal speech
Speech is intelligble

Advantages of TEP

Disadvantages of TEP:

1. Patient should manually cover the stoma while voicing

2. Good pulmonary reserve is a must

3. Additional surgical procedure is needed for insertion of prosthesis

4. Posterior pharyngeal wall could be breached inadvertantly

5. Catheter can pass through perforated posterior pharyngeal wall

Patient selection for TEP Insertion:

1. Motivated patient

2. Patient with a stable mind

3. Patient who has understood the anatomy and physiology of the process

4. Patient should not be an alcoholic

5. Patient should have good hand dextirity

6. Patient should have good visual acuity

7. Patient should have positive oesophageal insufflation test

8. Patient should not have pharyngeal stricture / stenosis

9. Patient should have good pulmonary reserve

10. Stoma should be of adequate depth and diameter

11. Tracheo-oesophageal wall should be intact

Contraindications of TEP Insertion:

1. Extensive surgery involving larynx and pharynx with separation of tracheo-oesophageal wall.

2. Inadequate psychlogical preparation

3. Patient's doubtful ability to cope up with the prosthesis

4. Suspected difficulty during post op radiotherapy

5. Impaired hand dextirity

Primary TEP:

Hamaker etal were the first to perform primary TEP in 1985. They concluded primary TEP should always be attempted whenever possible. In this type the tracheo-oesophageal prosthesis is inserted immediately during total laryngectomy surgery. Sufficient length of prosthesis should be used.

Advantages:

1. The risk of separation of tracheo-oesophageal wall is minimized
2. The tracheo-oesophageal wall is stabilized by the prosthesis to some extent
3. The flanges of the prosthesis protects trachea from aspiration
4. Stomal irritation is less
5. Important advantage is that patient becomes familiar with the prosthesis immediately following surgery.
6. Post op irradiation is not a contraindication

Because of the excellent exposure provided during total laryngectomy this surgery is rather easy to perform. This procedure is ideally performed before pharyngeal closure. The puncture is performed through the pharyngotomy defect. It is ideal to insert the Ryle's tube through this opening to facilitate early post-op naso gastric feeding. This tube is ideally left in place for at least 3 weeks.

Prosthesis used in TEP:
1. Blom-Singer prosthesis
2. Panje buttons
3. Gronningen buttons
4. Provox prosthesis

The Blom-singer and Panje devices should be taken out by the patients themselves for cleaning and reinsertion whereas Gronningen and Provox are indwelling prosthesis and need not be removed and cleaned.

Panje voice button:
This is a biflanged tube with a one way valve. This enables speech in laryngectomy patients by allowing air from trachea to pass into the oesophagus. It can easily be inserted into the tracheo-oesophageal fistula already surgically created for this purpose.

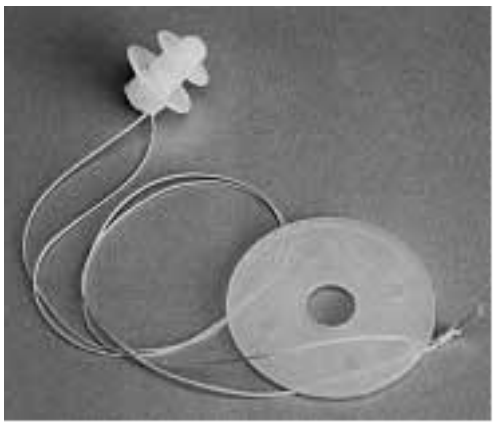
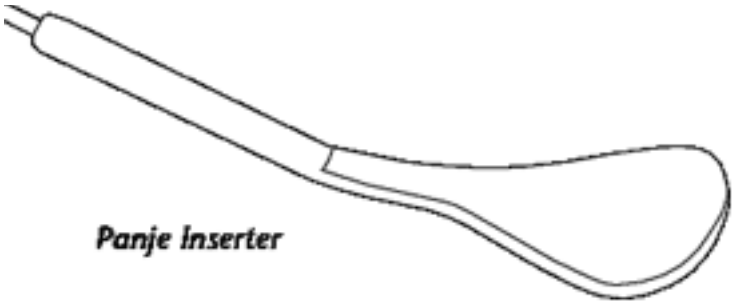


Figure showing Panje speaking valve



Usually an introducer is provided along with the prosthesis which makes introduction rather simple. This is a non-indwelling prosthesis and should be removed and cleaned once in 3 days.

Major advantage of Panje voice button is that it can be easily removed, cleaned and reinserted by the patient themselves.

Gronningen Button:

This TEP speaking prosthesis was introduced by Gronningen of Netherlands in 1980. Even though it was very useful initially, its high airflow resistance delayed speech development in some patients. With the introduction of low airflow resistance Gronningen button now it is getting popular among surgeons.

Blom – Singer prosthesis:

This device was first designed by Eric Blom, a speech therapist and Mark Singer a surgeon in 1978. They inserted this prosthesis into surgically created tracheo – oesophageal fistula. This prosthesis acted as a one way valve allowing air to pass from trachea into the oesophagus, and prevented aspiration into the trachea. This prosthesis is shaped like a duck bill. The duck bill end of the prosthesis should reach the oesophagus, while the opposite end shaped like a holed button rests snugly against the tracheostome. This is actually an indwelling prosthesis which can be safely left in place for at least 3-4 months without the need for cleaning.

Figure showing Blom-Singer prosthesis

This prosthesis is available in varying lengths (6mm – 28mm)
Classical Blom-Singer prosthesis is indwelling one. Since it needs higher pressure to open up it can cause problems in some patients. Currently low pressure Blom-singer prosthesis has been introduced. This is also made of medical grade silicone with a one way flapper valve replacing the duck bill. Only difference being the low pressure Blom-singer prosthesis is non-indwelling type and can be easily maintained by the patient.

Blom-singer dual valve prosthesis:

This prosthesis has two valves which ensures there is absolutely no risk of aspiration, while air is allowed to flow from the trachea into the oesophagus. This prosthesis is suitable in whom primary voice prosthesis has failed due to leak from oesophagus into the trachea.

Picture showing dual valve Blom-singer prosthesis

Provox prosthesis:

This is an indwelling low air flow resistance prosthesis. The advantage of this prosthesis is the extended life time. It can last anywhere between 1-2 years if properly used. Insertion and maintenance of this prosthesis is also pretty simple and straight forward.

Figure showing Provox prosthesis

The advantage of this prosthesis is the extended life time. It can last anywhere between 1-2 years if properly used. Insertion and maintenance of this prosthesis is also pretty simple and straight forward. Major problem with all these silicone prosthesis is candida growth 13. They are constantly exposed to candida from the oesophagus. They grow on the inner surface of the prosthesis preventing the one way valve from functioning.

Types of tracheo-oesophageal prosthesis and their features:

INDWELLING	NON INDWELLING
Can be left in place for 3-6 months	Must be removed and cleaned every 3-4 days
Requires specialist to do the job	Patients can do themselves easily
Less maintenance is required	Periodical maintenance is a must & patient should be trained for the job
Tracheostoma should be 2cms / greater	Tracheostoma should be greater than 2 cms
Patients should pass oesophageal insufflation test before insertion	Patients should pass oesophageal insufflation test before insertion

Secondary TEP:

This procedure is usually performed 6 weeks following laryngectomy. Secondary TEP allows time for the patient to develop oesophageal speech. Traditionally secondary TEP is usually performed with the help of rigid oesophagoscopy for direct visualization of the proposed TEP site. This procedure is performed under GA / LA. If planned under LA then flexible oesophagoscope is used to identify the TEP insertion area.
Current modified procedure followed by the author:

This procedure is performed under local infiltration anaesthesia. Patient is placed on the operation table in a recumbent position. A small roll of drape is placed under the shoulders of the patient to provide mild extension at the level of neck. The end tracheostomy tube is removed. 12 0 clock position of the tracheostome is clearly visualized.

Image showing the end tracheostome after removal of tracheostomy tube

Picture showing disposable Yanker's suction being introduced via the oral cavity

2% xylocaine with 1 in 100,000 adrenaline is injected via the tracheostome in the exact area where the tip of Yanker's suction hitches against.
Incision is made exactly in the area where the tip of Yanker's suction hitches at the 12 0 clock position of tracheostome.

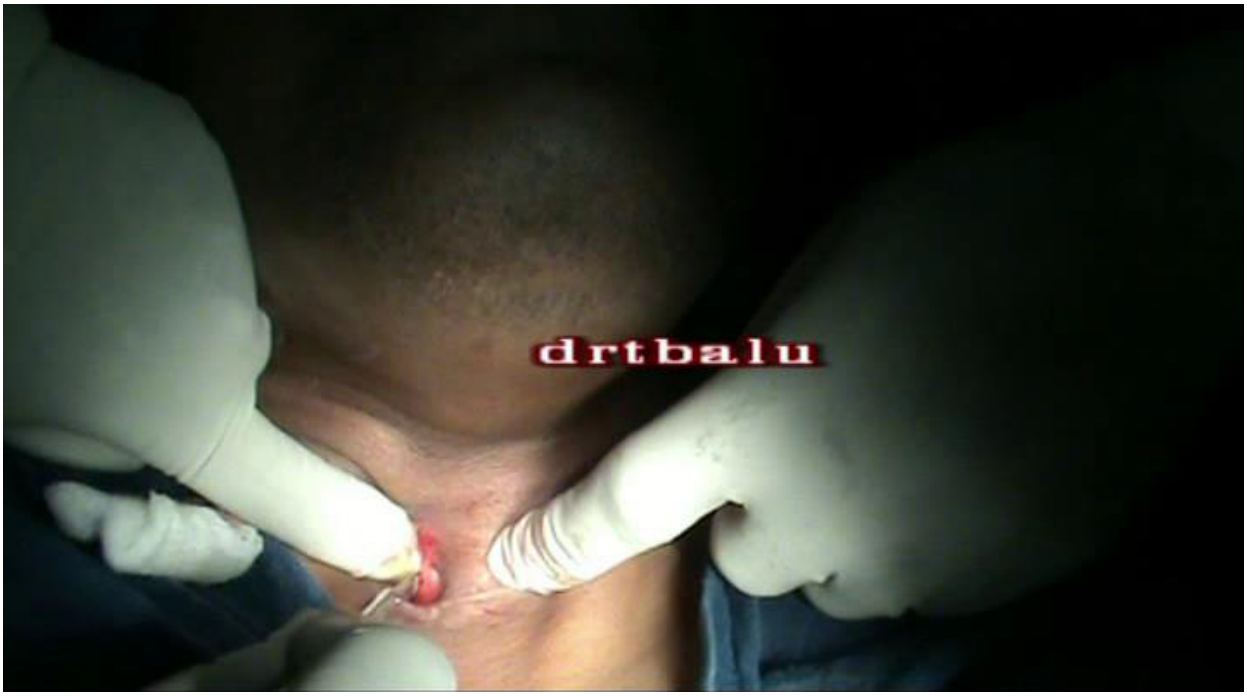


Figure showing incision being made using 11 blade

This incision is widened and deepened till the anterior wall of oesophagus is punctured. Care should be taken not to injure posterior wall of oesophagus. The tip of the suction in fact protects the posterior wall of oesophagus from injury. The puncture site is widened using a curved artery forceps. Minimal stomal diameter should be at least 2 cms.

After ensuring that the TEP is fairly widened, the Blom-singer Prosthesis is introduced and anchored with silk around the neck.

Figure showing curved artery forceps being introduced via the TEP site

Figure showing TEP in situ being anchored to the neck with silk

Problems of TEP Insertion:

1. Leakage through prosthesis
2. Leakage around prosthesis
3. Immediate aphonia / dysphonia
4. Hypertonicity problems
5. Delayed speech

Caution:

It is always better to perform transnasal oesophageal insufflation test before TEP insertion. This test will assess the response of pharyngeal constrictor muscle to oesophageal distension in these patients.
Trans nasal oesophageal insufflation test: The transnasal oesophageal insufflation test is a subjective test that is used to assess the pharyngeal constrictor muscle response to oesophageal distention in the laryngectomy patient.
The test is performed using a disposable kit consisting of a 50-cm long catheter and tracheostoma tape housing with a removable adaptor. The catheter is placed through the nostril until the 25-cm mark is reached, which should place the catheter in the cervical oesophagus adjacent to the proposed TEP. The catheter and the adaptor are taped into place. The patient is then asked to count from 1 to 15 and to sustain an "ah" for at least 8 seconds without interruption. Multiple trials are performed to allow the patient to produce a reliable sample.

The responses obtained are the following:
1. Fluent sustained voice production with minimal effort
2. A breathy hypotonic voice indicating a lack of cricopharyngeal muscle tone
3. Hypertonic voice
4. Spastic voice due to spasm of cricopharyngeus muscle

Rehabilitation following TEP:

Speech language pathologist should be actively involved in rehabilitation of patients following insertion of TEP prosthesis. The rehabilitation process starts while the patient is still hospitalized and is usually continued during the first week of surgery. During this period the speech and language pathologist should assess the tracheostome and site of TEP. Focus should be directed to identify leaks from inside or around the prosthesis. During this initial stage patient can be encouraged to communicate using artificial larynx. Intraoral type of artificial larynx is preferred.

Intermediate phase:
During this phase the patient is discharged from the hospital and is requested to attend Speech therapy sessions at least thrice a week. During this phase the patient should be informed of the type and size of the prosthesis. Breathing exercises are taught during this phase. Patient should learn how to push in air from the trachea into the oesophagus via the TEP.
Final phase / Phase of normalcy:
During this phase patient is able to communicate with near normal voice. Patient learns how to remove, clean and reinsert the prosthesis.

Common problems of TEP speakers are caused by:

1. Improper location of Tracheo-oesophageal puncture site

2. In appropriate size of the puncture

3. Presence of cricopharyngeal spasm

4. Leakage through and around the prosthesis

Location of TEP:
The puncture site is ideally located at 12 0 clock position in relation to the tracheostome. It is placed about 1 – 1.5 cms from the tracheocutaneous junction 14. If located superior to the stomal rim patient will find it difficult to occlude the stoma in order to produce speech. Similarly if the stoma is located deep inside the trachea then insertion of the prosthesis becomes rather difficult.

Size of the puncture:
This aspect is important for fluent speech. The size of the stoma should at least be 2 cms for production of fluent speech. If the size of the stoma is smaller than 2 cms it is prudent to enlarge it appropriately to benefit the patient.

Size of the prosthesis:
Appropriate size prosthesis should be chosen to avoid leak. Presence of leak from the prosthesis / around the prosthesis creates lots of problems. If leak occurs around the prosthesis then larger sized prosthesis should be chosen to avoid this problem.

Presence of cricopharyngeal spasm:
This again impedes production of fluent speech in these patients. This can be identified by performing Transnasal oesophageal insufflation test. If this test is positive then cricopharyngeal myotomy can be performed. Alternatively Botulinum toxin injection has reduced spasm of this crucial area. On an average 30 units of Botulinum toxin 15 when injected in to this area serves the purpose.

Leakage from / through the prosthesis:
Seen when inappropriate size of prosthesis is used (too small than the size of the stoma). Delayed leakage is caused due to colonization of the prosthesis by candida.
Management of leak:
Prosthesis can be removed and cleaned with brush and flushed with saline. Consumption of carbonated beverages helps in generating good quality voice. If leak is persistent then the shaft of the prosthesis can be plugged using q tip while swallowing food.

Cause	Solution
TEP location	Remove prosthesis allow TEP to close and repuncture
Unnecessary dilatation during routine placement	Defer dilatation and do it only when it is absolutely necessary
Thin tracheo-oesophageal wall 6mm / less	Select customized prosthesis
Prosthesis of incorrect length and size	Choose the correct sized prosthesis
Poor tissue integrity due to irradiation / chemotherapy	Choose custom prosthesis

Conclusion:

If performed accurately and fitted with proper prosthesis TEP is the best method for voice restoration in laryngectomy patients.

Drooling

Synonyms: Ptyalism, Sialorrhoea

Definition: Drooling is defined as unintentional loss of saliva from the mouth caused by inefficient unco-ordinated swallowing combined with a poorly synchronised lip closure.

Types of drooling:

a. Anterior drooling
b. Posterior drooling

Anterior drooling: In anterior drooling, saliva spills out of the oral cavity through the lips. This is common in infants under the age of 4. Any drooling occuring after the age of 4 should be considered pathological.

Posterior drooling: In posterior drooling saliva spills via the tongue over the fauces of tonsil. This type of drooling caused aspiration of saliva into the lungs.

Causes:

1. Physiological up the age of 4
2. Cerebral palsy
3. Hypersecretion of saliva
4. Elderly individuals because of poor oral muscular inco-ordination
5. Infections invoving the throat causing painful swallowing i.e. qunisy
6. Malignancy involving the postcricoid region and pyriform fossa
7. Following extensive surgical procedures involving the oral cavity
8. Drug induced (tranquilisers, anticonvulsants)

Problems of drooling:

1. Patients may have repeated peri oral skin breakdowns with infection.
2. Social embarrassment
3. Dehydration in extreme cases
4. Posterior drooling can cause coughing, gagging and aspiration

Pathophysiology of drooling: Drooling may be caused due to hypersecretion of saliva (i.e. Primary sialorrhoea). More commonly drooling is caused by impaired neuromuscular control of the oral cavity with imparied swallowing can also cause drooling. This is known as secondary sialorrhoea. In patients with cerebral palsy poor head positioning / contrrol due to reduced strength of neck muscles can cause drooling. Presence of an enlarged tongue (macroglossia) will compound the effect.

Elderly people due to dementia may forget to swallow their saliva and may hence drool. The presence of caries tooth, or gingival infection may accentuate drooling.

Saliva is secreted by three pairs of major salivary glands: Parotid, submandibular and sublingual glands. These glands secrete approxiamtely 1 - 1.5 liters of saliva / day. Submandibular glands are responsible for 70% of resting secretion of saliva. The parotid gland accounts about 20% of daily secretions. Parotid gland secretes only in response to a stimuli from food. The remaining 10% of secretions are from the sublingual and other minor salivary glands.

Management:

A good history is a must. This will go a long way in identification and successful management of the problem of drooling.
The severity of drooling may be classified thus:

1. Dry - Never drools
2. Mild - Only the lips become wet
3. Moderate - The lips and chin become wet
4. Severe - when cloathing becomes soiled
5. Profuse - When cloathing, hands and other parts of the body becomes wet

An assessment also should be made into the difficulties caused by drooling like:

1. Number of dress changes made per day

2. Difficulty in using key board / communication devices

3. Severity of peri oral skin excoriations

Physical examination: This includes

Assessment of head control and position

Look for perioral skin excoriations

Size of tongue should be assessed

Status of dentition and gingiva are assessed

Difficulty in swallowing must be looked for

Tonsils / adenoids must be examined

Nasal tissues should be examined for nasal blocks

Complete neurological examination is a must

Conservative treatment: Include speech and behavioural therapy. The goal of speech theapy is to improve jaw stability and closure, improving mobility of the tongue and lip closure. In order to obtain good results the therapy must be started at a very early age. Dental appliances that could reduce drooling have been tried with varying results. Adding to the difficulty in the managment is the fact most of the children with drooling are also mentally retarded.

Behavioral therapy includes positive reinforcement, cuing etc.

Medical management:

Drugs used in the management of drooling generally cause a reduction in the amount of saliva secreted. Drugs commonly used are glycopyrrolate and trihexyphenidyl. Among these two drugs glycopyrrolate is known to produce good results in majority of cases. Patinents invariably discontinue glycopyrrolate because of its unpleasant side effects like dry mouth, constipation, urinary retention and behavioral changes. Trihexyphenidyl may be of use in treating patients with cerebral palsy because of its beneficial effect on reducing dystonia in addition to reduction in salivary secretion. Botulinum toxin A has been currently tried with beneficial effects in treating patients with drooling. This drug can be injected into both salivary glands with the intention of reducing the basal salivary secretion rate.

Radiation therapy has also been atempted in managing severe cases of drooling which are refractory to other treatment modalities.

Surgical management:

1. Rerouting procedures
2. Removal of salivary glands
3. Ligation of salivary gland ducts

Surgery is indicated only when conservative management fails and the patient has severe drooling. Surgery should not be performed on a patient under 6 years of age.

Procedures performed to reduce salivary flow:

Methods available for surgical reduction of salivary flow are excision of salivary glands, ligation of salivary gland ducts or sectioning of nerves responsible for salivary secretion. Since 70% of basal salivary secretion is contributed by the submandibular salivary glands, bilateral excision of submandibular glands will help in the general reduction of salivary flow. Parotidectomy is frought with complications like injury to facial nerve hence should not be attempted to treat drooling. Contributions from the sublingual gland are negligible.

Trans tympanic neurectomy:

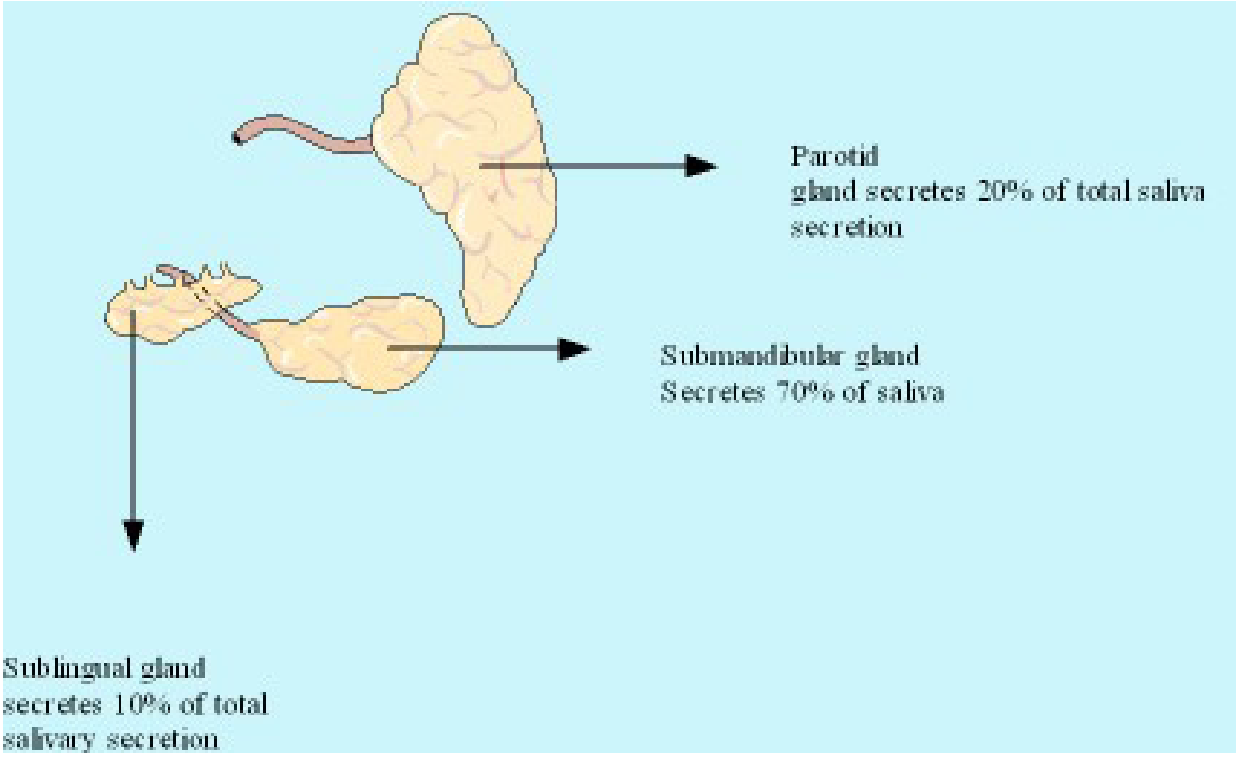
The parasympathetic supply to the parotid and submandibular glands are interrupted by sectioning these nerves in the middle ear. This is performed after elevation of tympanomeatal flap, sectioning of tympanic plexus at the promontory and sectioning of chorda tympani nerve as it passes close to the handle of malleus.

Wilkie procedure: This procedure involves excision of submandibular salivary glands, combined with ligation of parotid ducts on both sides. Parotid duct liagation is performed as below:
The opening of the parotid duct is first identified close to the upper second molar. The papilla is cannulated using a lacrimal duct probe. 1 - 2 cm of the duct is resected and removed. Facial duct ligation is a easy procedure and doesnot involve the risk of injuring the facial nerve.

Procedures performed to reroute salivary flow: Transposition of submandibular ducts on both sides posteriorly has been done attempted with considerable amount of success. The advantage of this procedure is that taste is preserved, and there is no dryness of mouth. This procedure facilitates the flow of salvia posteriroly.

Conclusion:

Successful management of drooling includes a multidisciplinary approach. Conservative methods should be exhausted before surgical procedures are contemplated.



BERA

Synonyms: Brain stem evoked response audiometry, Auditory brain stem response, ABR audiometry, BAER (Brainstem auditory evoked response audiometry).

Definition: Bera is an objective way of eliciting brain stem potentials in response to audiological click stimuli. These waves are recorded by electrodes placed over the scalp. This investigation was first described by Jewett and Williston in 1971.

Even though BERA provides information regarding auditory function and sensitivity, it is not a substitute for other methods of audiological evaluation. It should be always viewed in conjunction with other audiological investigations.

Procedure: The stimulus either in the form of click or tone pip is transmitted to the ear via a transducer placed in the insert ear phone or head phone. The wave froms of impulses generated at the level of brain stem are recorded by the placement of electrodes over the scalp.

Electrode placement: Since the electrodes should be placed over the head, the hair must be oil free. The patient should be instructed to have shampoo bath before coming for investigation. The standard electrode configuration for BERA involves placing a non inverting electrode over the vertex of the head, and inverting electrodes placed over the ear lobe or mastoid prominence. One more earthing electrode is placed over the forehead. This earthing electrode is important for proper functioning of preamplifier.

Since the potentials recorded are in far field, well displaced from the site of impulse generation, the wave forms recorded are very weak and they need to be amplified. This amplification is achieved by improving the signal : noise ratio.

How to improve signal to noise ratio: Three parallel approaches are designed to achieve this goal.

Filtering: This is employed to reduce the recording bandwidth so that only the important components of the siganal generated are recorded.

Repeated stimulation: This is done with synchronous time domain averaging to increase the amplitude of the components of the signal. In real time situations these two can be achieved by connecting the recording electrodes to a preamplifier, with appropriate filter settings.

Polarity alteration: By altering the polarity of impuses recorded, the artifacts are cancelled making the brain stem waves stand out.

In auditory brain stem evoked response audiometry, the impulses are generated by the brain stem. These impulses when recorded contains a series of peaks and troughs. The positive peaks (vortex positive) are referred to by the Roman numerals I - VII.

These peaks are considered to originate from the following anatomical sites:

1. Cochlear nerves - waves I and II

2. Cochlear nucleus - wave III

3. Superior olivary complex - wave IV

4. Nulclei of lateral lemniscus - wave V

5. Inferior colliculus - waves VI and VII

These peaks occur in most readable form in response to click stimuli over a period of 1 - 10 milliseconds after the stimulus in normal hearing adults.

BERA is resistant to the effects of sleep, sedation, sleep and anesthesia. Its threshold has been found to be within 10dB as elicited by conventional audiometry.

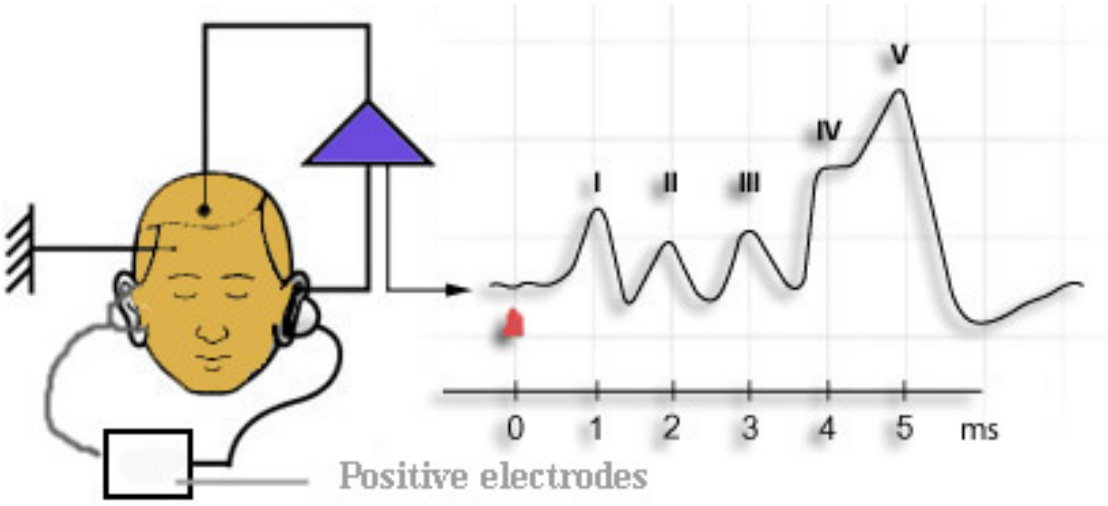


Figure showing placement of BERA electrodes

There are two different types of auditory evoked potential tests. These tests are being used as an adjunct to routine diagnostic testing. The two types of auditory evoked potential tests are: 1. Auditory brain stem response and 2. Auditory cortical response.

Auditory cortical response: Records the impulses generated by brain in response to tone stimuli. It is recorded using cortical response audiometry (CERA). CERA is very useful for threshold estimation of hearing, where as BERA is highly useful for objective threshold estimation of hearing as well as differential diagnostic purposes. These reponses are more generalised and originate form the brain cortex occurring between 50 - 300 milliseconds after the onset of stimulation. Since these responses are generally elicited with a tone burst lasting approximately for about 200 milliseconds, its responses are highly frequency specific. This is in contrast to BERA because brain stem responses are evoked by click stimuli and are not frequency specific. Interpretation of CERA is easy and straightforward. Threshold is defined as the minimum stimulus level that gives a consistent and identifiable response. The patient must be lying still during the recording process. This test is hence unsuitable for young children who may not co-operate

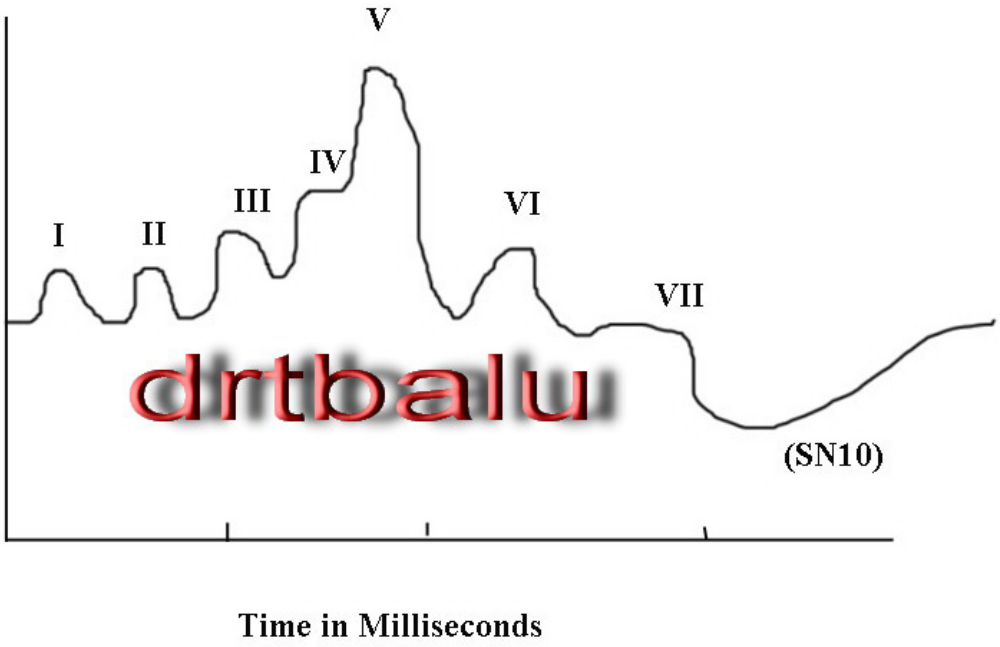


Illustration showing various wave forms of BERA

DIFFERENCES BETWEEN BERA AND CERA

BERA	CERA
Recording is made from brain stem potentials	Recording is made from cortical potentials
Click stimulus is used	Tone stimulus is used
Responses are not frequnency specific	Responses are frequency specific
Can be performed in awake and restless patients	The patient must lie still through out the process
Responses begin after 1 - 10 milliseconds after stimuli	Response begins after 50 - 300 milliseconds after stimulation
Suitable for even young children	Unsuitable for children

Uses of BERA:

1. It is an effective screening tool for evaluating cases of deafness due to retrocochlear pathology i.e. (Acoustic schwannoma). An abnormal BERA is an indication for MRI scan.

2. Used in screening newborns for deafness

3. Used for intraoperative monitoring of central and peripheral nervous system

4. Monitoting patients in intensive care units

5. Diagnosing suspected demyelinated disorders

BERA findings suggestive of retrocochlear pathology:

1. Latency differences between interaural wave 5 (prolonged in cases of retrocochlear pathology)

2. Waves I - V interaural latency differences - prolonged

3. Absolute latency of wave V - prolonged

4. Absence of brain stem response in the affected ear

BERA has 90% sensitivity and 80% specificity in identifying cases of acoustic schwannoma. The sensitivity increases in proportion to the size of the tumor.

Criteria for screening newborn babies using BERA:

1. Parental concern about hearing levels in their child
2. Family history of hearing loss
3. Pre and post natal infections
4. Low birth weight babies
5. Hyperbilirubinemia
6. Cranio facial deformities
7. Head injury
8. Persistent otitis media
9. Exposure to ototoxic drugs

COMET

(Combined Microscopic and Endoscopic surgical technique)

Introduction: Endoscopic sinus surgery has grown in leaps and bounds. With better understanding of the mucociliary mechanisms in clearing the sinuses has made the endoscopic surgeon more conservative. In this surgical modality two optical systems are used surgically to treat nose and paranasal sinuses.

The optical systems used are:

1. Optical microscope

2. Nasal endoscope.

This combination of both optical systems for the same surgical procedure is called combined microscopic and endoscopic technique (COMET surgery).

The microscope commonly used in this surgical procedure is the Zeiss, with 300 mm objective lens. The optimal magnification preferred is 6 x.

Major parameters of optical systems used in this surgery:

1. Focal distance (working distance)

2. Depth of field (focus)

3. Numerical aperture

4. Field of view

5. Resolution

6. Brightness

7. Distortion

8. Protection

Focal distance: (working distance) is defined as the distance between the object and the first surface of the lens system. For optimal surgical results this distance should be really a comfortable one. The maximum working distance should not exceed the length of the operating surgeons arm. The working distance increases when the focal length of the objective lens is increased. As far as the microscope is concerned this is optimally 300 mm.

Figure showing Endoscope and Operating Microscope

When using a microscope the head of the surgeon is held steady behind the eyepiece, the focus is adjusted by simply turning a knob provided for this purpose. Both the hands are incidentally free for purposes of manipulation.

In the case of an endoscope, the focal distance is fixed and cannot be adjusted. The working space is also limited. The head and one of the hand of the surgeon will have to move to keep the operating field in focus.

Depth of field (focus): is defined as the distance by which the image may be shifted longitudinally with reference to the retina of the viewer's eye without blur. This is actually the visible depth of the object. A microscope understandably provides a much larger field of depth, making the surgeon really comfortable. Where as in an endoscope the depth of field is shorter, and hence the endoscope should be moved constantly to increase its field of depth.

Numerical aperture: This is related to the depth of field (focus), the luminance and the resolution of the system. The numerical aperture of the microscope is smaller and hence more light is required to illuminate the target area. The resolution limit is also smaller than that of an endoscope. This aperture can be varied and adjusted.

In an endoscope the numerical aperture is higher and the image hence looks brighter, with better finer details. However the numerical aperture is fixed and cannot be adjusted.

Field of view: In the case of microscope the field of view is more extended, and the surgeon is able to follow the movement of almost the whole of the surgical instrument, where as in the case of an endoscope, the field is much smaller and hence only the tip of the surgical instrument used will be visible.

Resolution: is defined as the minimal distance which is necessary to separate two points in a surgical field. In the case of a microscope, the resolution limit is smaller, but can be varied and adjusted. In the case of an endoscope the resolution is higher, giving finer details in a clear form. However the resolution is fixed in the case of an endoscope.

Luminance: Is defined as the brightness of an image. In the case of a microscope the luminance is smaller, but can always be increased by using a bright light. The endoscope has a higher luminance. Since the tip of the endoscope acts as the light source, surgical instruments with highly reflective surfaces whne held close may cause distortion and saturation of images.

Cleanliness / protection: This is vital in any surgery to prevent any post operative infections. In the case of a microscope all the optical systems are far away from the surgical field, and hence is ideally protected. The endoscope however must be place close to the operating field, hence is prone for staining, fogging and scratching.

Optical characteristics	**Microscope**	**Endoscope**
Focal length	0.5 - 100 mm	0.2 - 5 mm
Magnification	5x - 5000x	2x - 26x
Numerical Aperture	0.10 - 0.96	0.25 - 0.7
Resolution power	<430 l p/mm	250 - 400 l p/mm
Field depth	Few micrometers	Micrometers to nanometer
Field of view	6 - 20 mm	30 - 120 degrees (different scopes)
Distortion	Small	Large

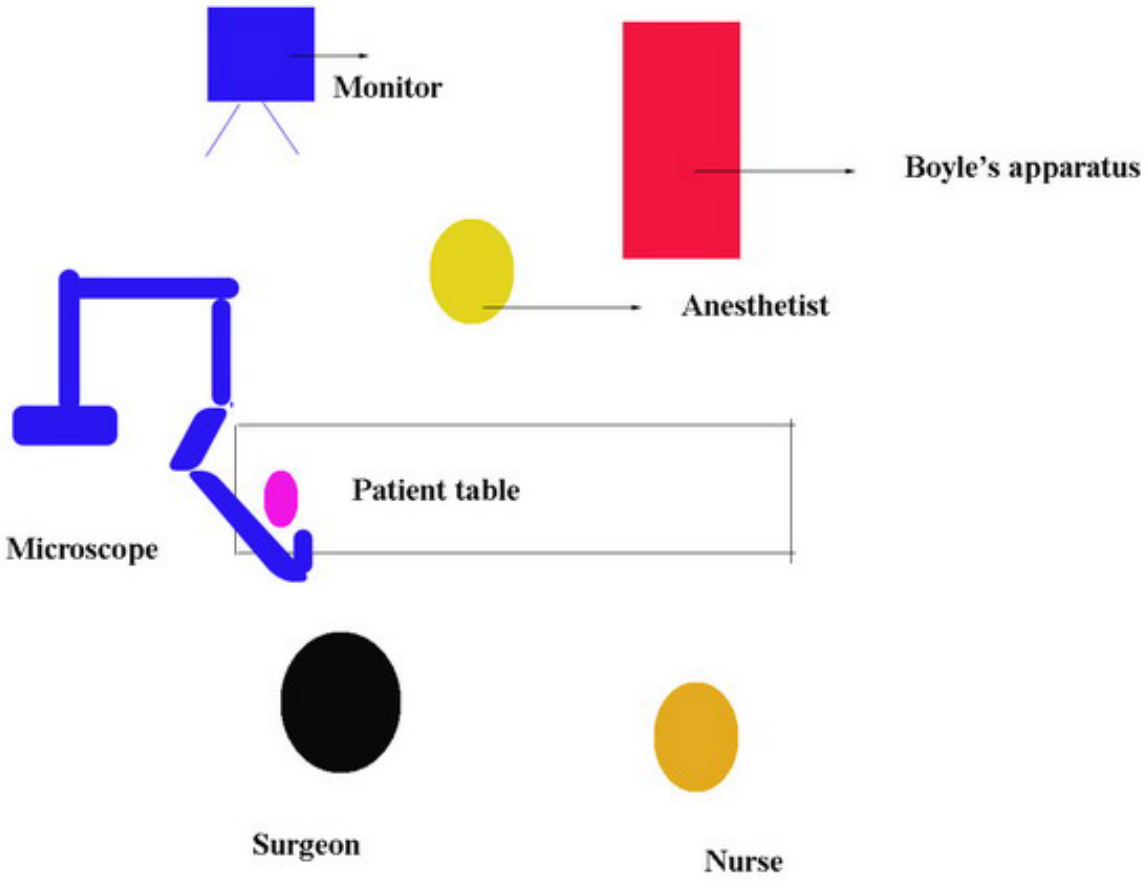
Ergonomics of a microscope: The major advantage of a microscope is that it is rigid, self supported and positioned far away from the surgical field. The field of view is large, with a good depth of field. The major advantage being both the hands of the surgeon are left free for manipulation.

Ergonomics of an endoscope: The endoscope provides good image clarity, and resolution. By changing the endoscope angular vision is possible. The major disadvantage is that one hand is occupied for manipulation of the endoscope, leaving only one hand for surgical instrumentation.

By judicious combination of both these excellent optical instruments ideal surgical results can be achieved in COMET surgery.

Procedure:

The surgery is ideally performed under general anesthesia. The patient is placed in supine position, with head slightly elevated and gently rotated towards the surgeon.



Theatre layout for comet surgery

The surgeon should be standing, with the patient's nose right in front of his eyes.

General anesthesia is preferred because of its obvious advantages. The oropharynx should be packed with moist gauze. Before intubation the nasal cavity of the pateint is packed with gauze impregnated with 1% xylocaine with 1 in 100,000 adrenaline. This helps to shrink the nasal mucosa and the turbinates making visiblity of insides of nasal cavities easy.

1. Septoplasty is performed if necessary for access. If needed this step may be done under microscopy.

2. Management of middle turbinate comes next. Concha if present must be removed.

3. Unicinectomy is performed under microscopy.

4. Maxillary antrostomy: This includes removal of diseased mucosa, irrigation with warm normal saline. The maxillary sinus is visualised using

a angled endoscope. Residual disease from inside the sinus cavity should be removed.

5. Ethmoidectomy (partial or total according to situation)

6. Frontal sinusotomy (performed using endoscopes angled), with irrigation with normal saline.

7. Sphenoidotomy using angled telescopes. Irrigation with normal saline is performed.

8. Removal of inferior turbinate if necessary.

Staging Protocols in Sinusitis

Aim of staging rhinosinusitis:
1. To decide on the severity of disease process
2. To decide on the optimal treatment modality
3. To decide the prognosis of disease

Various attempts were made to evolve a viable and effective staging protocol for rhinosinusitis.

1. Princetown staging (1993): This staging protocol was evolved at the international conference on sinus disease at Princetown. In this staging protocol CT scan assessment was extensively resorted to. Plain radiographs of paranasal sinuses were excluded from the staging protocol.
Each sinus group (maxillary, anterior ethmoid, posterior ethmoid, sphenoid and frontal) is graded separately as 0 when there is no abnormality, 1 when there was evidence of partial opacification, and 2 when there is total opacification.
The osteomeatal complex is taken next for staging purposes. It is scored as 0 when there is no obstruction, and a score of 2 is awarded if there is osteomeatal block.
Anatomical variants if any are noted. They do not contribute to the overall score. These variants are important when surgery is being planned. The variants include concha bullosa, paradoxical middle turbinate, Haller's cell, everted uncinate process, agger nasi pneumatisation, and absence of frontal sinus.

Since CT images are extensively resorted to in this staging protocol, when it should be taken is a very important point. CT scan for staging purposes is best obtained after adequate medical management, and during a period when there is no acute infection (3-4 weeks after acute or subacute infection).

Patient symptom data has also been used in this protocol. The patient is asked to grade his symptoms in a grade scale ranging from 0 -10. The grading symptoms include nasal block, congestion, nasal pressure, head ache, olfactory disturbance and discharge.

Nasal endoscopic examination also contributes to the quantification of the staging process. It takes into consideration the presence of polyps, discharge, edema, scarring, adhesions and crusting. The scoring protocol is as follows:

0- Absence of polyp
1- Presence of polyp confined to the middle meatus
2- Presence of polyp beyond the middle meatus

0-No discharge
1-Clear and thin discharge
2-Thick and purulent discharge

Friedman and Katsantonis staging protocol: (1984)

Stage I: Single focus disease shown radiographically, either unilateral or bilateral.
Stage II: Discontiguous or patchy areas of disease either unilateral or bialteral.
Stage III: contiguous disease throughout the ethmoidal labyrinth, with or without sinus opacity with symptomatic response to medication
Stage IV: contiguous hyperplastic disease involving all the sinuses, with minimal or no symptomatic response to medications

Patients with stage I disease were treated medically. Most patients in stage II undergo surgical intervention. Almost all patients belonging to Stage III and Stage IV disease will have to be operated on to treat the condition.
Stage III and IV disease with asthma is more prone for recurrence following surgery.

Gliklich and Metson system:

Stage 0: Less than 2mm mucosal thickening on any sinus wall
Stage I: Include all unilateral disease or anatomical abnormalities
Stage II:Bilateral disease limited to the ethmoid or maxillary sinuses
Stage III: Bilateral disease with involvement of atleast one sphenoid or frontal sinus
Stage IV: Pan sinusitis

Lund and McKay system: Uses a scoring and localization system. Points are given for the degree of opacification.
0 points = No abnormality
1 point = Partial opacification
2 points = Total opacification

Sinuses are identified as:
Maxillary
Anterior ethmoid
Posterior ethmoid
Sphenoid
Frontal

Osteomeatal complex obstruction:
0 points = no obstruction
2 points = obstruction
Each side is scored separately

Pillar Procedure to treat Snoring

Introduction: The vibrations and collapse of soft palate contribute to the pathophysiology of snoaring and sleep apnoea. When this tissue flutters / vibrates during breathing causing snoaring to occur. The collapse of upper air way tissues (soft palate, uvula, tonsils and adenoid) can cause obstruction to the upper airway. The collapse is more during sleep because there is no support for these tissues, and hence has a tendency to collapse.

How the pillar implant system works?

The Pillar Palatal Implant System changes the soft palate structure and its response to airflow. In this procedure three implants are placed into the muscles of soft palate. These implants not only adds support to the soft palate, it also stiffens it preventing it from fluttering during the process of inspiration. As in the case of jet panes where the maximum amount of lift is generated below the wings, the maximum amount of lift forces are generated at the junction of the hard and soft palate. Insertion of implants in this area prevents these forces of lift.

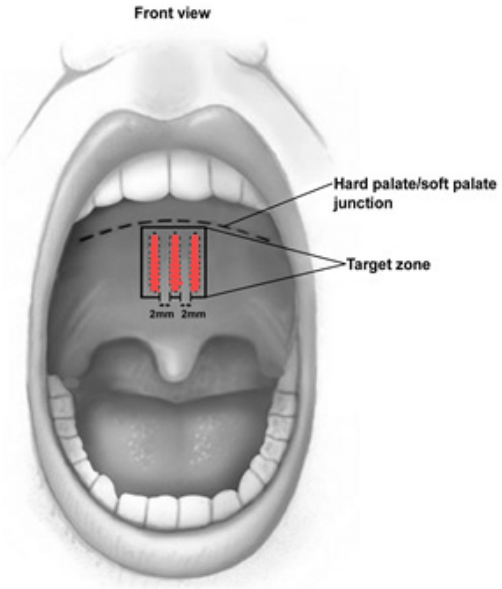
The body's healing process comes in to play after the insertion of these implants. These implants stimulate fibrosis and overgrowth of fibrous tissue around the implant further stiffens it. This stiffening increases the "critical" air speed required to initiate palate movement, leading to a decrease in snoring and a reduction in the ability of the soft palate to obstruct the airway.

These implants should be placed as close to each other as possible without coming in to actual contact. The minimum distance should be atleast 2mm from the implant. This distance is a must for optimal fibrous deposition.

Indication: Pillar implants are indicated in

1. Reduction of snoaring caused by flutter of soft palate

2. Reduction of sleep apnoea in patients with upper air way obstruction



Theory behind the implant procedure:

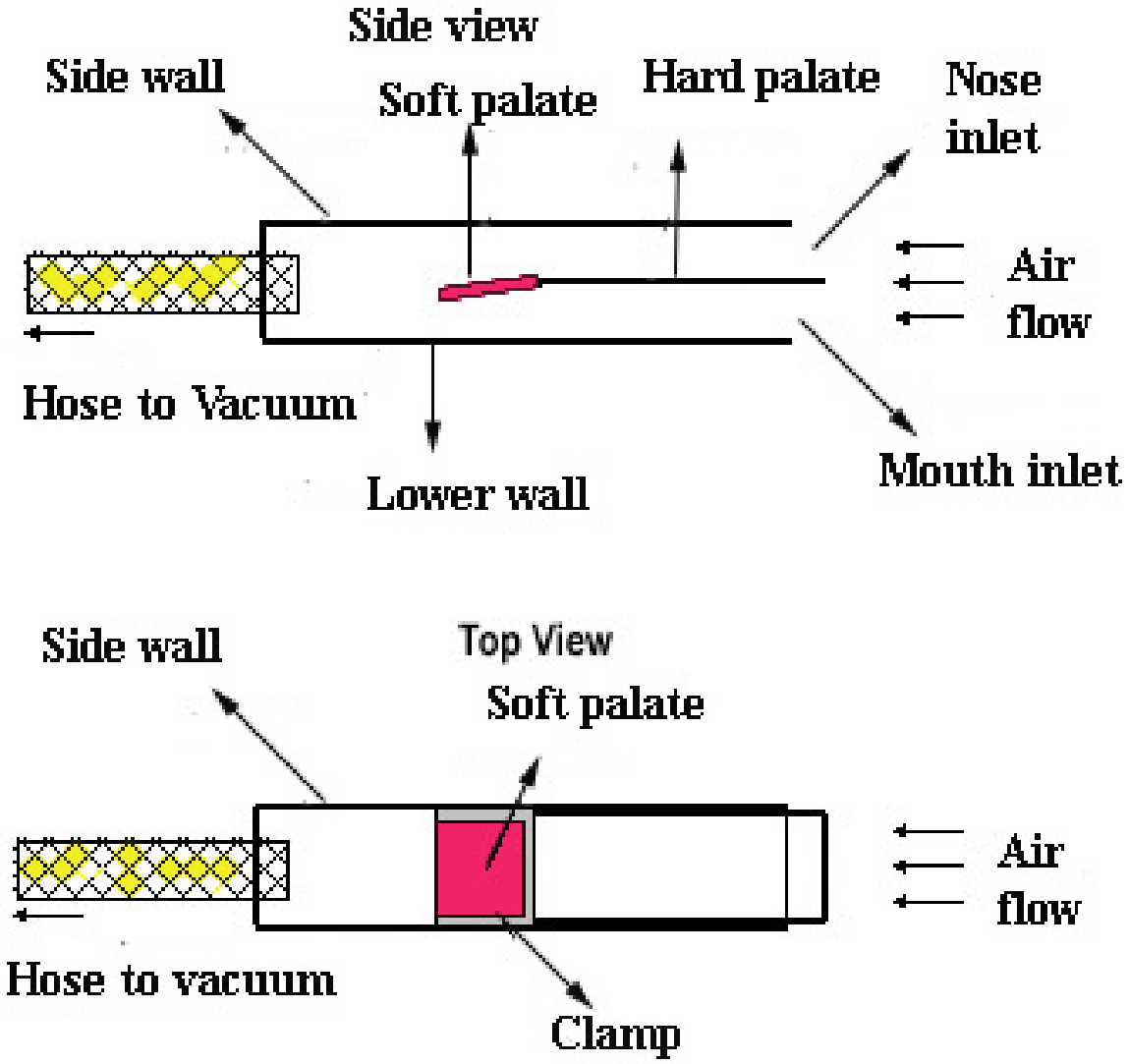


Figure showing the aerodymanic theory behind the pillar procedure

Figure above shows the aerodynamic model constructed to explain the theroy behind the implant procedure. This model consists of four walls that replicate the human upper airway. These four walls form a channel. The channel is attached to a vacuum system that draws air into the model, simulating inhalation by the lungs. A partition is placed between the upper and lower walls of the channel replicating the palate dividing the incoming air flow into the nose and mouth inlets. The walls of the channels are clear so that the movements of the soft palate can be noticed during the air flow. The palatal osscilation can be clearly studied. Tapes can be used as stiffening agent in this model, and clamped together. This procedure simulates the function of an implant. This experiment proves that stiffening of the palate causes a significant increase in the airway pressure needed to cause rattling of the soft palate.

Three scenarios are studied:

Movement of non stiffened soft palate:

1. increasing air speed causes palate to vibrate in a wave motion.

2. motion can be clearly seen to begin at the junction of the hard and soft palate

3. motion is transmitted from the palate to the uvula

Movements of palate stiffened at the uvula end:

1. stiffening of the uvula does not reduce palatal motion

2. greatest aerodynamic lift is experienced at the junction of hard and soft palate

Movements of palte stiffened at the jucntion of hard and soft palate:

Stiffening the soft palate closer to the hard palate junction reduces vibration by:

1. Affecting the region of greatest aerodynamic lift

2. Preventing the onset of vibrating motion

Type of material which can be used as implant:

The implant consists of multiple polyester fibers woven together into precise specifications. The implant design requires that two ultrasonic welds melt the fibers together creating a depression at the surface of each end to prevent unraveling.

The pillar implant can be performed as a stand alone single step office procedure, of it can be combined with other procedures which could alleviate upper airway obstruction. The implant is precisely inserted using a specially designed gun.

Figure showing the special gun used for the procedure

Physiology of Nose and sinuses Recent Trends

Introduction: Physiology of paranasal sinuses have undergone rapid advancement since the days of Galen. It was Galen who described the anatomy of paranasal sinuses as "Porosity of skull" in the second century AD. It was Leonardo da vinci who made a detailed anatomical illustration and description of the paranasal sinuses. His illustrations contained description of frontal sinuses and maxillary sinus ostium.

The physiological role played by paranasal sinuses have always been conjectural. Several hypothesis have been made. For easier understanding these hypothesis have been grouped under three main heads:

1. Structural theories

2. Evolutionary theories

3. Functional theories

Structural theory:

Fallopio's theory: Fallopio in 1600 hypothesized that these para nasal sinuses are present to make the skull bone lighter thereby reducing the load on neck musculature which supports the head.

Another theory belonging to this group suggests that these sinuses contribute to the maintenance of equilibrium and the positioning of the head by lightening the anterior portion of the cranium.

Proetz theory: suggests that the paranasal sinuses play a role in remodelling of facial bones.

Evolutionary theory: This theory is very innovative. It considers the paranasal sinuses as the evolutionary response of anthropomorphic monkeys to shift from terrestrial environment to the aquatic one. This theory was proposed by Hardy. According to him the African monkeys were forced to take to water when the whole of Africa was surrounded by sea about 6.5 million years ago. The necessity to cross large stretches of water enabled them to develop these air filled sinus cavities which helped them to keep afloat for long hours in water. This occured due to an evolutionary process known as Natural selection.

Functional theories:

Bartholini's theory: Bartholin considered these cavities as organs of resonance which added quality and resonance to the voice.

Cloquet's theory: Cloquet hypothesized that paranasal sinuses contained olfactory epithelium aiding in the function of smell. This theory has been disproved as olfactory epithelium has not been demonstrated in the sinus cavity.

The most acceptable theory is that these sinuses improves nasal function. The fact that these paranasal sinuses embryologically originates as invaginations from the nose and its histological continuity with the nasal mucosa leads credence to this theory. These sinuses have been shown to strengthen the defence function through additional secretion of lytic enzymes and immunoglobulins.

Ventilatory function: Since the mucosal lining of the paranasal sinuses are in continuity with that of nasal mucosa they play an important role in ventilatory function. Gaseous exchange are known to occur between the inspired air and blood supply of the sinus mucosal lining. Gaseous exchanges are determined by active and passive phenomena. During respiration the nasal valve transforms the inspired air into a laminar flow. When this laminar flow reaches the middle meatus area turbulence starts to occur. This turbulence causes uniform mixing of air. There is a pressure gradiant between the nasal cavity and para nasal sinuses causing airflow in to the sinus cavities. Air enters the sinuses at the end of every inspiration and at the begining of the following expiration. This is because only during these times a positive pressure exists in the nasal cavities driving air into the sinuses.

Figures showing air entering and leaving maxillary sinus cavity

It has been estimated that only 1/1000 of the air volume inside the sinuses are exchanged through a single respiratpry act. The patency of the ostium is verfy important for the gaseous exchange to take place.

Mucociliary clearance: The nose and paranasal sinuses form the first line of defence for the lower airways. They protect the lower airways from noxious substances and microbes. They play a vital role in specific and non specific modes of defence. Among the nonspecific protective mechanisms, mucociliary clearance play an important role. This mechanism depends on the integrity of the mucociliary system which includes the ciliated cells, goblet cells and the quality of the mucous secreted. Goblet cells are more numerous in maxillary sinus than other sinuses. The mucociliary transport mechanism needs continuous supply of oxygen. This mechanism clears the nasal and sinus cavity. The microbes and particulate matter if any gets entrapped in the secretions and are transported out.

Immune defence: This defence mechanism can be divided into nonspecific (phylogenetically older) and specific (phylogenetically newer) mechanisms. The older non specific mechanism is also known as natural immunity. This is brought about by factors like:

1. Lysozyme - which destroys the bacterial cell wall

2. Interferon

3. Complement

4. Enzymes

Specific immunity is provided by macrophages and immunoglobin secreting lymphocytes. This immunity is highly specific against microbes invading the nasal cavity. Nose associated local immune tissue (NALT) has been attributed with this function.

Recent trends in the management of Frontal Sinusitis

Introduction: The size and the anatomy of frontal sinus is highly variable. It drains into the middle meatus via the killians infundibulum. This infundibulum opens in to the frontonasal recess. The drainage of frontal sinus is directed downwards, gravity assists its drainage. Because of this dependent drainage feature, acute sinus infections involving frontal sinuses heals fast and the patients respond well to conservative management.

Importance of frontal recess: The width and the course of frontal recess is dependent on the size and number of anterior ethmoidal cells. Some of these cells may encroach into the frontal sinus (frontal cells, or frontal bulla). The more this frontal recess is curved, the more frontal cells develop into the frontal sinus. These cells obstruct the drainage from frontal sinus, causing acute sinusitis to become chronic. The presence of these frontal cells will mislead the surgeon into assuming he is already inside the frontal sinus when infact he has just opened the frontal cell.

Development of frontal sinus: Frontal sinus is absent at birth. It begins to appear only at 6 months of age. Developmentally it arises from:

1. Direct extension of frontal recess

2. From one or more of anterior ethmoidal air cells

3. From the ventral extremity of ethmoidal infundibulum

It is this embryological origin which is responsible for the mucous patterns which may recirculate in the frontal recess along its medial wall.

History:

Headache caused by frontal sinusitis has a classic periodicity. It is more when the patient gets up from the bed in the morning and gets better as the day progresses. This feature is due to the beneficial effects of gravity assisted drainage.

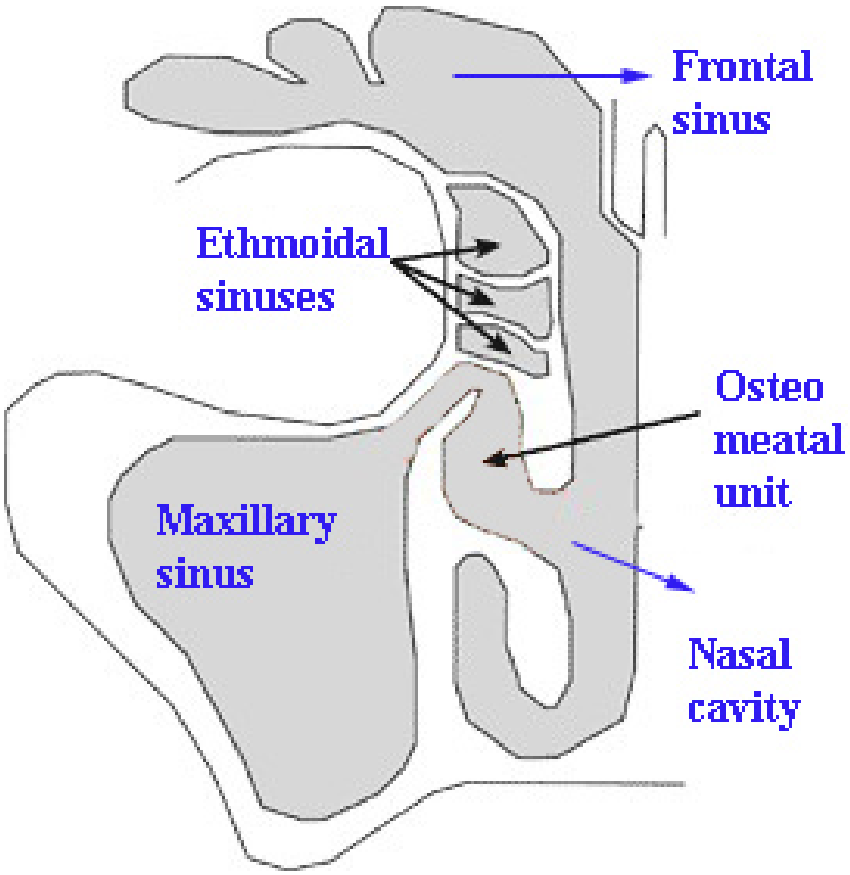
Clinical examination:

Inspection & palpation: The anterior frontal sinus wall is examined for any signs of redness of skin / bulging. Tenderness may also be elicited by percussing the anterior wall of frontal sinus. This is a fairly reliable sign of acute frontal sinusitis. If percussion is painless in a patient with a bulge over frontal sinus then frontal mucocele should be suspected. Another way of eliciting frontal sinus tenderness is using the thumb to apply pressure over the floor of the frontal sinus. Pressure should be applied behind the supra orbital rim and not over the supra trochlear or supra orbital foramen, where tenderness could be easily elicited due to irritation of branches of supra orbital nerves.

Anterior rhinoscopy may not be useful to examine frontal sinuses. It is better to used angled telescopes to examine the frontal sinus recess area.

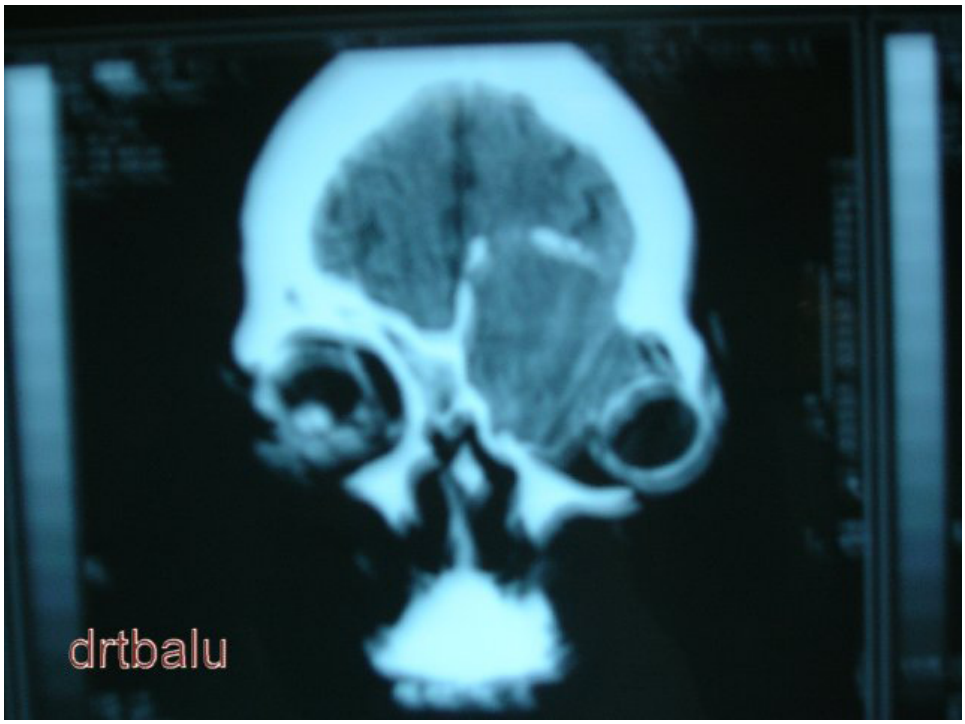
Role of Xray paranasal sinus: Nowadays this is not acceptable as the only only imaging modality. This could be useful for templates to be cut in frontal osteoplastic surgical procedures.

CT scan of paranasal sinuses is the gold standard in the diagnosis of frontal sinusitis.



Anatomical variations of frontal recess plays a very important role in the pathogenesis of frontal sinusitis. Majority of cases of frontal sinusitis respond well to medications and conservative management. Surgery is indicated only in those intractable cases where there is long lasting obstruction to its drainage channel.
Various surgical approaches to frontal sinuses:

Frontal sinus trephination: This is the oldest surgical intervention for acute purulent frontal sinusitis. A 1 cm incision is made just above the medial end of the eyebrow, and a small hole (0.5cm) is drilled over the anterior wall of the frontal sinus and the sinus cavity is entered. An endoscope may be used to examine the sinus cavity. Irrigation of the sinus cavity can be performed under endoscopic control. Irrigation should be done with extreme care if a defect of the orbital roof is seen on the CT.



CT scan paranasal sinuses showing enlarged left frontal sinus with proptosis (Frontal mucocele)

External frontoethmoidectomy: A slightly curved incision is made towards the medial canthus of the eye down to the level of the bone. This incision should divide the distance between the nasal dorsum and the medial canthus of the eye in the middle as shown in the figure.

The ethmoidal cell system should be dissected with care. The end result would be a single cavity encompassing the nose, ethmoids and frontal sinuses.

One basic conceptual error is encountered in this surgical procedure. Nearly 2/3 of the bony margins of frontal sinus drainage is resected in this surgical procedure causing excessive scarring. This could result in mucocele formation. Hence to avoid this potential complication, a stent should be left in place atleast for a period of 6 months.

Another important problem with this surgical procedure is the potential risk of injury to supra orbital and supra trochlear nerve. Patients also develop double vision postoperatively in 40% of cases.

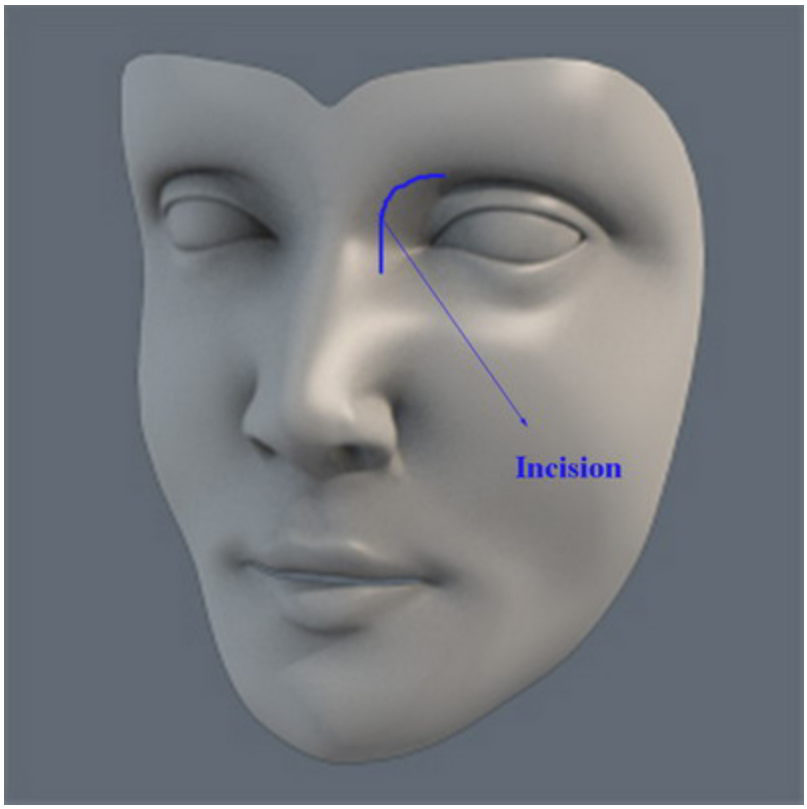


Figure showing the incision

The frontal sinus is opened up by resecting the lacrimal bone, part of the frontal process of maxilla and the frontal sinus floor.

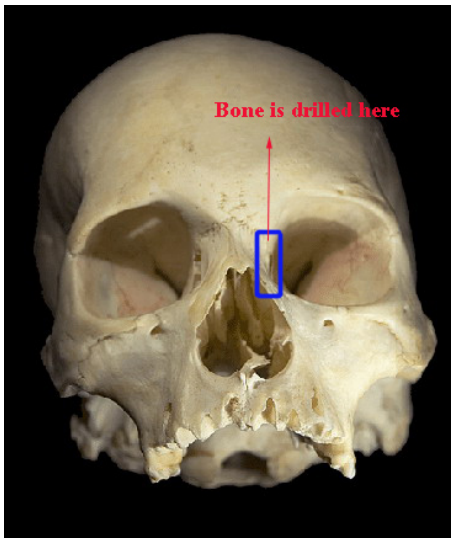
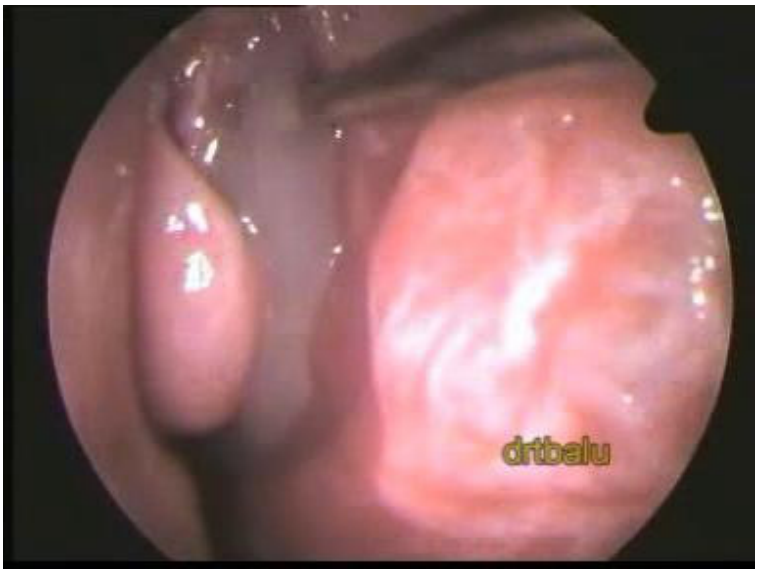


Figure showing the area of skull bone which must be drilled

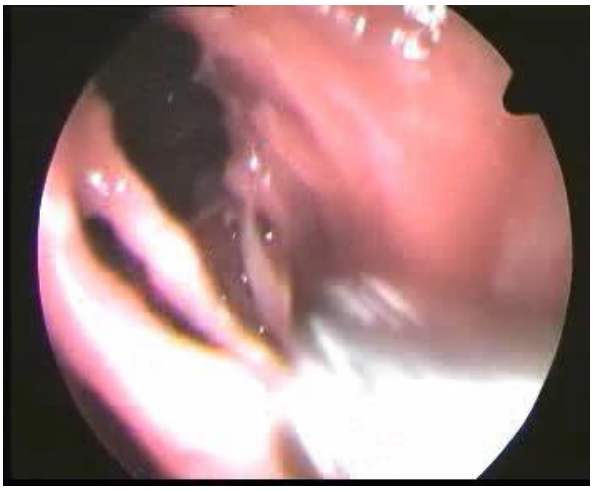
Endonasal surgical drainage procedures:

Various types of endonasal surgical procedures are being practised. These include:

Type I: Simple drainage procedure: This is accomplished endonasally by ethmoidectomy including the cell septa in the region of frontal recess. The inferior portion of killian's infundibulum and its mucosa is left undisturbed for fear of stricture developing. This procedure will be helpful when there is only a minor pathology in the frontal sinus, and the patient is free of risk factors like aspirin intolerance and asthma. These risk factors are associated with poor quality of nasal mucosa, causing unpredictable results. In majority of cases the frontal sinus heals spontaneously because of improved drainage.



Pus seen extruding after frontal recess area was cleared



Frontal sinus ostium widened

Type II or Extended drainage: This is of two types. Type IIa and Type IIb.

Type IIa: This procedure is performed by resecting the floor of the frontal sinus between the lamina papyracea and the middle turbinate.

Type IIb: This procedure is performed by resecting the floor of the frontal sinus between lamina papyracea and nasal septum anterior to the ventral margin of the olfactory fossa.

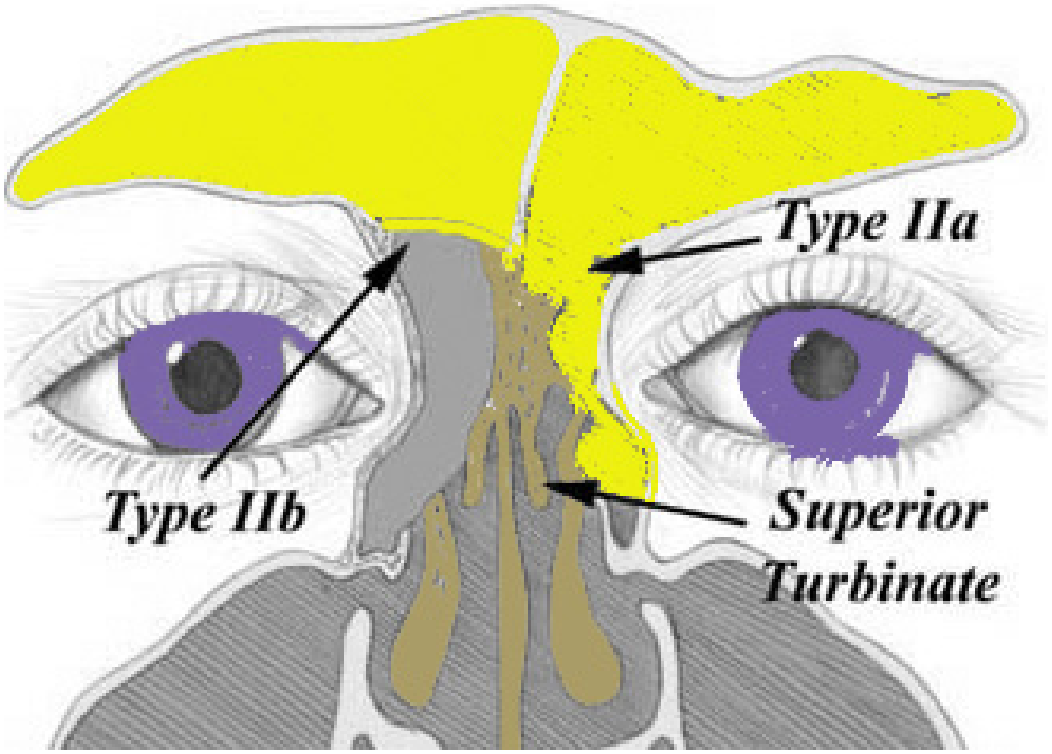
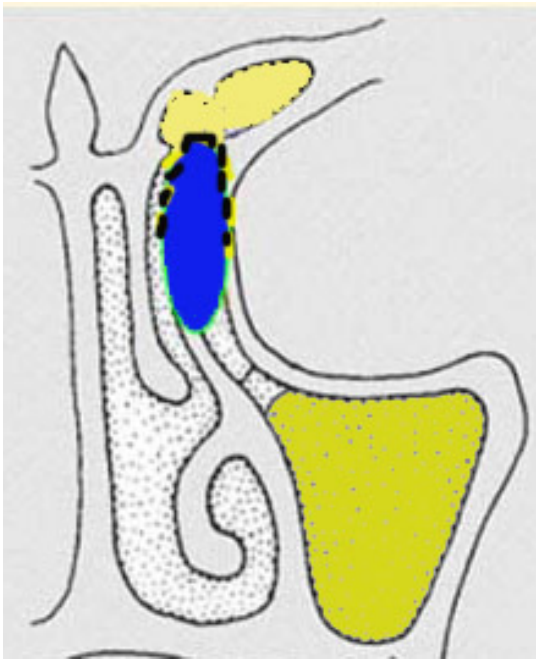


Figure showing Type II drainage procedure

It has been assessed that the maximum size of the neoostium of frontal sinus that can be achieved in Type IIa procedure is 10 mm with a mean of 6mm. Somewhat larger opening can be created in Type IIb type of drainage procedure.

Preoperative CT scan may reveal the presence of socalled frontal cells. These are anterior ethmoidal air cells that has encroached into the frontal sinus giving a false impression that the frontal sinus has been properly opened. If these frontal cells are present, a procedure known as uncapping the egg is performed resulting in type IIa drainage.



A large ethmoidal cell (blue) could be seen extending up to the level of frontal sinus. The frontal sinus could be drained only by uncapping this large ethmoidal air cell (frontal cell). This procedure is known as the uncapping the egg. (Black dotted lines)

Type III: (Endonasal median drainage)

When frontal sinusitis is due to either bone or dense scar from prior surgery obliterating the communication of the frontal sinus to the nose, one approach to restoring drainage is to remove the entire floor of both frontal sinuses. This procedure is known as a type III frontal sinusotomy.

The elements of type III frontal sinusotomy are removal of the entire floor of both frontal sinuses, the intrasinus septum which divides the frontal sinus into a left and right cavity and upper nasal septum. To achieve the maximum possible opening of the frontal sinus, it would be helpful to identify the olfactory fibers on both sides. The middle turbinate is exposed and cut from anterior to posterior along its origin at the skull base. After cutting about 5mm the olfactory fibers could be seen coming out. This should be repeated on the opposite side also, resulting in a so called “frontal T”. In performing this procedure both endoscope and microscope should be used.

In revision cases, type III drainage can begin from possible two points, from the lateral of medial side. The primary lateral approach is advisable if previous ethmoidal surgery was incomplete and the middle turbinate is still present as a landmark. Primary medial approach is justified if previous ethmoidal surgery was complete, and the middle turbinate is absent. The medial approach starts with the partial resection of the perpendicular plate of ethmoid of the nasal septum, followed by identification of the olfactory fibers on each side.

Frontal sinus rescue procedures: These procedures are indicated to clear up frontal sinus obstruction by laterally retracted middle turbinate and scar tissue. See figure below:

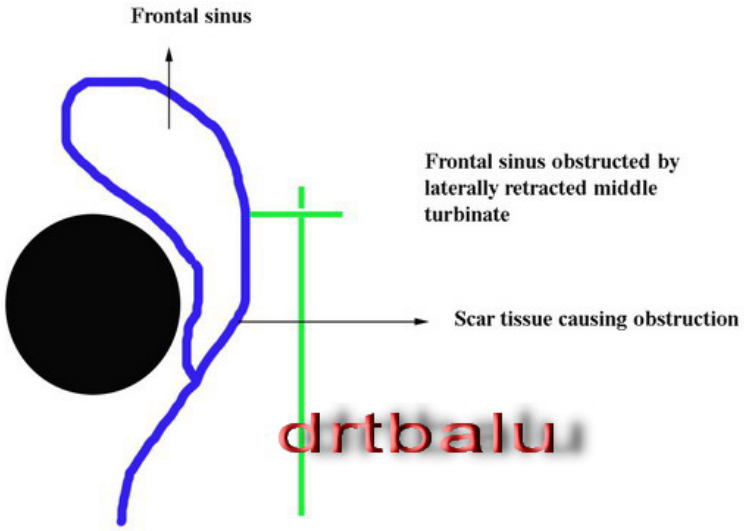
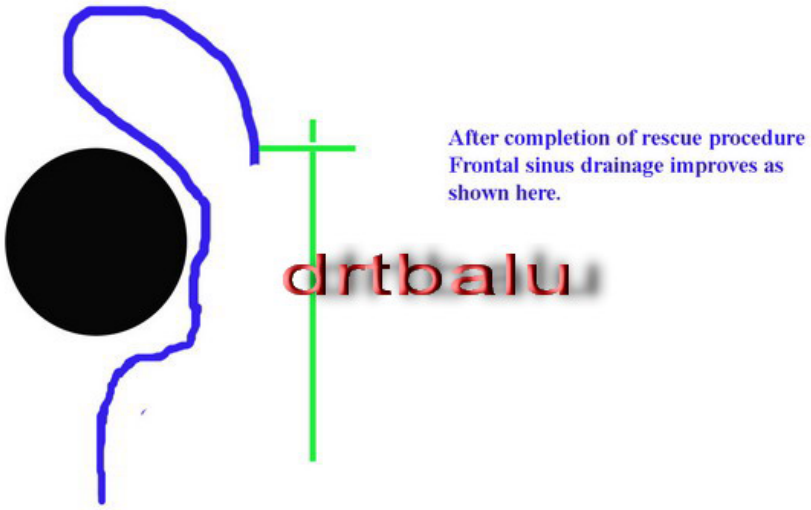


Figure showing obstruction of frontal sinus by scar tissue / laterally retracted middle turbinate.



Frontal sinus neoostium after completion of rescue procedure.

The scar tissue obstructing the frontal sinus drainage is resected first. After resection of scar tissue the remnant of middle turbinate becomes visible.

The medial osseous and mucosal lamina of middle turbinate are resected, the lateral mucosal lamina is preserved. This lateral mucosal lamina is turned medially

covering the skull base. The frontal sinus neoostium is epithelized.

Rhinofrontal sinuseptotomy: Combined intra and extra nasal approach

This procedure is useful to manage difficult frontal sinus disease which has recurred even after repeated surgeries. This procedure was first developed by Stenert.

Surgical steps include:

1. External approach

2. Resection of frontal sinus pathology

3. Total resection of frontal intersinus septum

4. Partial endonasal resection of nasal septum

5. Bilateral subtotal resection of free dependent part of middle turbinate

6. Bilateral endoscopic ethmoidectomy

7. Enlargement of the isthumus area between both frontal sinuses and nasal cavities

8. Complete epithelization of neocommunication with free mucosal grafts.

Osteoplastic bone flap procedure is an external approach used in difficult inflammatory conditions involving the frontal sinus.

Indications:

1. Failure of Type III drainage procedure

2. Type III drainage procedure cannot be performed because the antero posterior diameter is less than 8mm

3. Laterally located mucopyocele

4. Major destruction of posterior sinus wall

5. Inflammatory complications following trauma

6. Correction of Pneumatosinus dilatans

7. Benign tumors involving frontal sinus

Role of Tinnitus maskers in the management of Tinnitus

Introduction:

The central idea of tinnitus masking involves use of ear level wearable devices that deliver sound to the patient's ears. The very idea behind this device is to reduce the annoyance caused by tinnitus. This relief is achieved by masking the sound of tinnitus or reducing the intensity of the tinnitus in some way. Complete releif from tinnitus involves complete masking, while partial relief involves partial masking. These devices allow patients themselves to choose the form of sound that produces complete relief. Ideally the sound which is used to mask tinnitus should be presented to the ear on a continuous basis.

Tinnitus maskers:

Tinnitus maskers play a vital role in the management of tinnitus. Use of tinnitus maskers reduces the incidence of tinnitus in these patients.

Types of tinnitus maskers:
There are three different masking devices used in the management of tinnitus. The exact type used depends on the degree of patient's hearing loss, and the nature of tinnitus.

Type I: Conventional hearing aids. These conventional hearing aids produce masking of tinnitus by amplifying ambient noise which in turn covers up or masks the tinnitus. These hearing aids are useful in patients who have tinnitus associated with hearing loss.

Type II: These are classic tinnitus maskers that generate noise bands which can be adjusted by the user. The user can choose the noise band and the optimal volume that masks the tinnitus

Type III: Tinnitus instruments. These are a combination of both a high frequency hearing aid and a tinnitus masker within the same apparatus. Both these components have separate volume controls that can be used to adjust them individually.

Image showing tinnitus maskers

Differences between Tinnitus Masking and Conventional masking

Conventional Masking	Tinnitus Masking
Consistent between individuals	Highly inconsistent
Frequency specificity / critical band is important	Critical band is unimportant
Optimal masking is achivable	Optimal masking is difficult to achieve
Sound parameters easy to measure	Sound parameters of tinnitus difficult to measure

Indications of various tinnitus maskers:

1. Patients with normal hearing commonly have high frequency hearing loss and hence should use tinnitus maskers that generate masking sounds with substantial high frequency content (6kHz and above).
2. Patients with high frequency hearing loss associated with high pitched tinnitus should use tinnitus instruments (type III).
3. Patients with low frequency hearing loss with associated low pitch tinnitus would benefit from using well fitted hearing aids. These hearing aids are sufficient to produce masking effect on the tinnitus.

It is always important to adjust the tinnitus masker so as to generate the lowest level of masking sound that is capable of masking the tinnitus.
If tinnitus is troublesome during sleep then bedside maskers can be used. Masking pillows are also available.

Tinnitus masking by using bone conduction of ultrasound: One recent advancement in tinnitus masking is the development of a new wearable high frequency bone conduction maskers. These maskers can be applied anywhere over the skull without the need to occlude the external auditory meatus.

Role of alprazolam in the management ot tinnitus

Alprazolam: the commonly used anxiolytic drug has demonstrated beneficial effects in the management of tinnitus. This was in fact an accidental finding when a large number of patients who were suffering from anxiety and tinnitus were prescribed this drug to relieve anxiety. A majority of them reported relief from tinnitus also. At first this beneficial effect was attributed to the fact that a less anxious patient will be able to handle tinnitus better.
Further studies have without doubt demonstrated the beneficial effects of the drug.

Dosage regimen: There is a high degree of variability in the patient response to tinnitus and the dose of drug administered. After a lot of trial and error the following dosage schedule has been evolved:

1. Weeks 1 and 2 - 0.5 mg alprazolam is prescribed each evening before bed time. This dose is not sufficient to relieve tinnitus, but it allows patients to adapt to the drowsiness that is associated with the drug usage. Patients should be warned about this problem of drowsiness.

2. Weeks 3 and 4 - 0.5 mg alprazolam is given in twice a day dose (morning and evening). If this dose fails to relieve tinnitus then this drug should be continued in the same dose indefinitely, under supervision of the physician.

3. Weeks 5 and 6 - the dosage administered can also be increased to thrice a day. If the patient derives benefit the patient can continue the drug indefinitely under supervision

4. If the benefit is not sufficient to the patient's liking then the drug can be tapered off and discontinued. The tapering dose is as follows:
0.5 mg aprazolam twice a day for 3 days and then once a day for 3 days. Eventually the drug is stopped on the 7th day.

Evaluation Methadology of Lacrimal and Orbital disorders

Introduction: Tears which are produced by the main and accessory lacrimal glands are mostly drained by the lacrimal drainage system. Any disorder affecting the lacrimal system causes the complaint of tearing (epiphora). Excessive tearing could be caused by hypersecretion from the tear glands or insufficient drainage of tears through the lacrimal drainage system. In this article we will be evaluating the various evaluation methodologies available to study lacrimal and orbital disorders.

Role of History taking: This is the most underestimated but a very important aspect of evaluation methadology. Patient should be queried with intention of identifying whether epiphora is cased secondary to overproduction of tears or due to inefficient drainge of the secreted tears.

In epiphora due to overproduction of tears, the problem will be bilateral, and is associated with minimal eye discharge or crusting. Tearing due to insufficient drainage by contrast will be mostly unilateral, and is associated with eye discharge and crusting. Crusting will be more evident on getting up from sleep. In patients with complete obstruction of lacrimal drainage system, infection commonly develops in the lacrimal system causing swelling, redness, and tenderness in the medial canthal region. Lacrimal sac infections (dacryocystitis) is associated with pain around the eye. In pediatric patients this may progress to orbital / periorbital cellulitis.

Figure showing a patient with epiphora

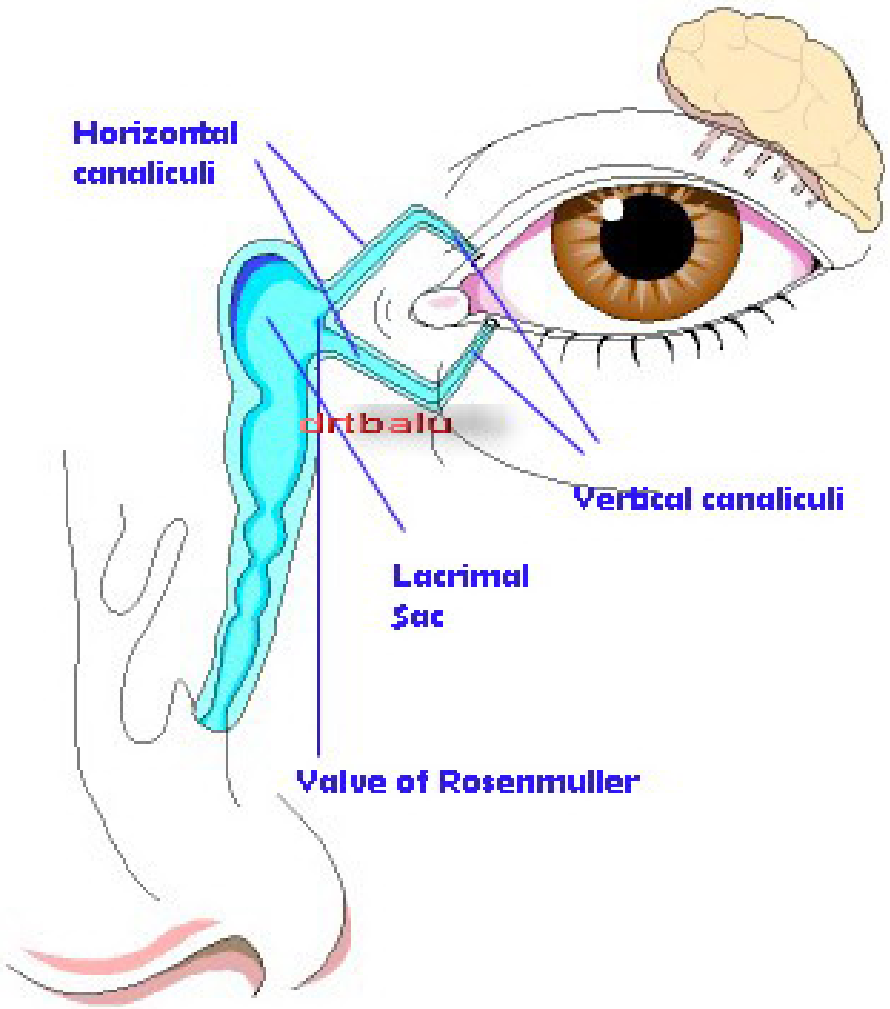


Figure showing the anatomy of lacrimal apparatus

Clinical examination: The aim is to confirm infromation obtained in the history. It also helps in evaluating which segment of the lacrimal drainage apparatus is obstructed.

The examination includes:
1. Inspection of the eyelid position, contour and function in relation to the operation of the lacrimal pump. Malpositions of eyelid such as ectropion, where in the punctum is not apposed to the globe will always be associated with epiphora.

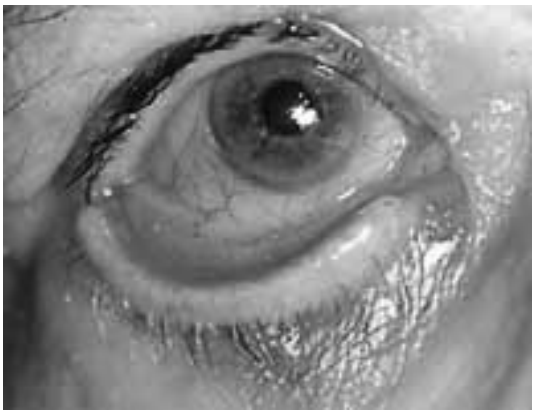


Figure showing Ectropion

2. Facial nerve palsy may lead to paralytic ectropion / weakness of orbicularis muscle. Weakness of orbicularis oculi may affect the lacrimal pump mechanism. Contractions and relaxations of orbicularis oculi is neccessary for tears to be pumped into the lacrimal sac.

3. Punctal abnormalitis: This condition sould be carefully looked for. Punctal ectropion may be associated with epiphora. Each punctum should be assessed for patency. Normal punctum is usually 0.3 mm in diameter. Congenetial / acquired stenosis of the punctum may interfere with tear drainage mechanism. Swelling / erythema around the punctum may signify canaliculitis. In these cases pressure over the canaliculus may cause tear reflux, while pressure over lacrimal sac area does not show any reflux. The canalicular area should be palpated carefully to seek evidence of calculi.

4. Palpation over the medial canthal area may reveal a mass in the area of lacrimal sac, in patients with significant lower tear drainage channel obstrution. Lacrimal sac tumors must be diligently excluded by palpating this area. In patients with significant lower lacrimal drainage channel obstruction, palpation over lacrimal sac area will cause pain with reflux of tears / secretions / pus. If the reflux is purulent then significant dacryocystis should be suspected.

5. Intranasal examination: This is a must. All suspected patients should undergo diagnostic nasal endoscopic examination to rule out sinonasal causes of lacrimal outflow obstruction.

6. Slitlamp examination: Will reveal elevation of precorneal tear film.

7. Diagnostic tests: Many tests have been designed to localize obstruction in the lacrimal outflow system. These tests either individually or in combination is useful in the diagnosis.

Schirmer's test: This test is basically prepared to quantitate tear production. This test is performed by placing strips of white filter paper at the junction of the middle and lateral thirds of the lower eyelids after administration of a topical anesthetic agent. The tear production is measured with the eyes closed. Produced tears will wet the filter paper. The length of the filter paper which becomes wet is assessed at the end of 5 minutes. Normal test result is between 10mm and 30 mm of wet filter paper. Normally it should not exceed 30 mm. A value of more than 30 mm is considered to be epiphora. A value of less than 10 mm is considered to be dry eye (hyposecretion).

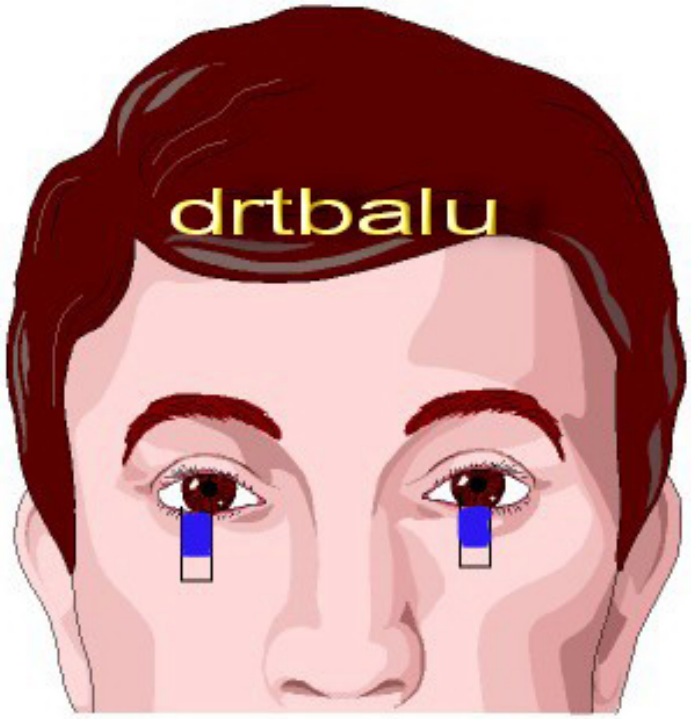


Figure showing schirmer's test being performed

Fluorescein dye disappearance test: This test can be easily performed as an office procedure. The steps are as follows:

A mixture of topical anesthetic and flurescein dye is placed in the inferior fornix of each eye. The tear film formed in each eye is observed and compared over a period of 5 - 10 minutes. This dye should drain rapidly through a patent lacrimal drainage system. Persistence of dye in the tear film even after 10 minutes indicates abnormal lacrimal outflow. This could be due to functional / anatomic obstruction in the lacrimal drainage apparatus.

Figure showing flurescein dye disapperance test being performed

Punctal dilatation and canalicular probing: This simple test is used to evaluate patency of the proximal ductal system. Difficulty with dilatation may indicate clinically significant punctal stenosis. Similarly difficulty with probing through the canaliculus may indicate canalicular stenosis / stricture. This is a contraindication for endoscopic dcr. Drainage may improve if probing opens up the stenosed canaliculi. Easy probing up to the superior portion of lacrimal sac is a good indicator of upper lacrimal drainage pathway patency.

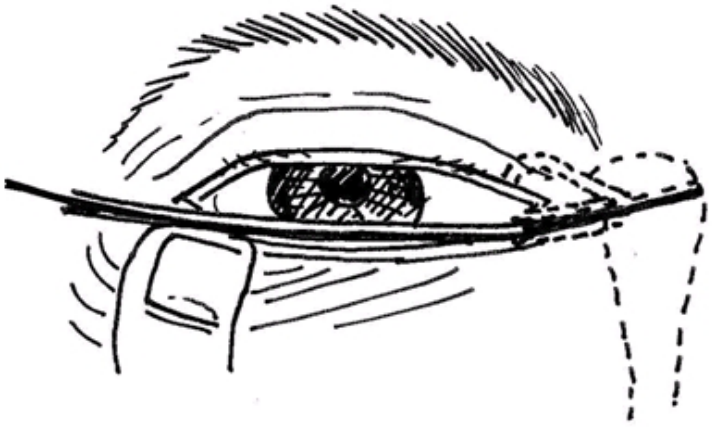


Figure showing lacrimal probing being done

Lacrimal irrigation: This test is used to diagnose the location and extent (complete / partial) of an obstruction. A 23 - 27 gauge cannula is attached to a syringe containing sterile saline solution. This is introduced into the proximal canaliculus (usually the lower one) following punctal dilatation. Irrigation should be performed in both eyes even in patients with unilateral epiphora, since the normal eye can be used as the basis of comparison. In the presence of patent / partially patent lacrimal system the saline finds its way into the nasal cavity. Reflux of the injected saline through the same punctum indicates canalicular obstruction, while reflux from the opposite punctum indicates obstruction distal to the common canaliculus. Distention of lacrimal sac or reflux of purulent secretion indicates nasolacrimal duct obstruction. Reflux of bloody fluid indicates lacrimal system inflammation, a lacrimal sac tumor, or trauma to the tissues while introducting the cannula.

Jones dye tests: This group of tests are used to distinguish between functional and anatomic outflow problems. The primary test is performed by placing topical anesthetic and flurescein dye into the conjunctival sac. Topical 4% xylocaine and oxymetazoline nasal sprays may be used to anesthetize and vasoconstrict the inferior meatus of the nose. A cotton tipped applicator is placed beneath the inferior turbinate near the opening of the nasolacrimal duct. Recovery of fluorescein dye in the nose indicates a functionally and antomically patent system. Non recovery of the dye (negative result) suggests a functional or anatomic blockage.

In the event of negative dye test, secondary dye test should be performed. This test is performed after removal of residual fluorescein from the conjunctival sac. Clear saline solution is placed into the inferior canaliculus using a syringe / cannula. The irrigant is retreived from the nasal cavity by tilting the patient's head forward over a basin. If fluoresein dye is present in the irrigant (positive result) then it is assumed that the upper lacrimal system is functional while the lower system is partially open and is not functional. Recovery of a clear irrigant (negative result) indicates a functional problem with the upper system.

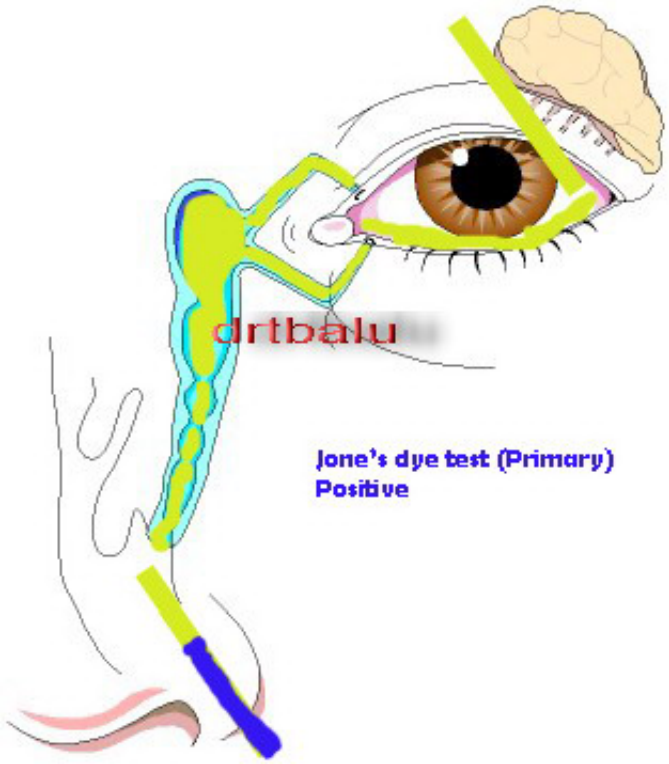


Figure showing Jone's dye test (Positive)

Dacryocystogram: This test helps to evaluate the anatomy of the lacrimal system. In this test contrast medium is injected into the lacrimal system through the lower canaliculus, and performing a serial radiography. The anatomy of the complete outflow system becomes visible. This test is useful in identifying congential anamolies involving the lacrimal outflow tract.

Evalation of orbit: This must serve to distinguish orbital from periorbital, intraocular and sinonasal disorders. The most commonly encountered orbital disorders of interest to an otolaryngologist are 1. Grave's disease and 2. Orbital fractures.

Grave's disease: Also known as Thyroid eye disease is diagnosed in the presence of hyperthyroidism. The irony is that it could be present even in euthyroid or hypothyroid patients.

Criteria for diagnosis of thyroid eye disease:

1. Presence of eyelid retraction: This is one of the major criteria. In the presence of eyelid retraction the diagnosis can be made in the presence of one of the following: Thyroid dysfunction, exophthalmos, optic nerve dysfunction or extraocular muscle involvement.

2. In the absence of lid retraction, the diagnosis can be made in the presence of thyroid dysfunction along with one of the following: exopthalmos, optic nerve dysfunction, or extraocular muscle involvement.
Presenting symptoms:

1. Ocular irritation / discomfort

2. Conjunctival injection / tearing

3. Diplopia

4. Proptosis

5. Lid retraction

When proptosis is symmetrical the patient may miss it.

Extraocular muscle inflammation and enlargment in Grave's disease my limit eye movement and cause double vision. Eye muscle function can be evaluated by determining the alignment of the globes in the primary position and accessing its mobility. Cover - uncover test will reveal even mild misalignments.

Observation of upper eyelid movement may be helpful in the evaluation of thyroid eye disease. Normally, upper eye lid descends smoothly and competely with downward rotation of eye as seen in downward gaze. When this movement is delayed or incomplete then it is known as the lid lag, which is a feature of thyroid eye disease.

Lagophthalmos: is defined as incomplete closure of eyelids. This is commonly seen in thyroid eye disease.

Proptosis: Is defined as forward protrusion of eyeball. This can be measured using an exopthalmometer.

Orbital fractures:

Symptoms include:

1. Pain

2. Diplopia (commonly seen in blow out fractures)

3. Facial numbness

4. Trismus

5. Periorbital oedema

6. Ecchymosis

7. Orbital emphysema

8. Hypoesthesia of cheek and upper lip (seen in fractures of orbital floor)

Gamma Knife Stereotactic radiosurgery in ENT

Definition: This procedure involves fixing a rigid stereotactic frame to the patient's head, which acts as a reference, defining the volume it encloses in a set of X, Y, and Z co ordinates. This is combined with radiological images can be used to target tumors and pathologies involving the skull base. Radiation is then delivered using gamma chambers. The fundamental difference between radiosurgery and irradiation is that in radiosurgery it is delivered as a single high dose rather than a fractionated course as seen in irradiation.

Differences between irradiation and radiosurgery:

Irradiation	Radiosurgery
Delivered in fractionated doses	Delivered as a single high dose
Need not use precise targetting	Should be precisely targetted
Gamma knife is not needed	Gamma knife is needed. It contains an array of 201 cobalt sources
Pathological tissue should be more radiosensitive than normal surrounding tissue	Since the beam is highly focussed the radiosensitivity of the tumor mass is not an issue

Figure showing the Gamma knife

The dose of radiation used in stereotactic radiosurgery has a steep shoulder (rapid fall off), and because of this feature it spares the surrounding tissues.
Procedure:

The procedure perse has four steps.

First step: A stereotactic frame is fitted to the head under local anesthesia.

Second step: Radiological images, generally MRI are acquired.

Third step: The scanned images are processed using Gamma plan which is a radiosurgery planning software. This helps in the calculation of cumulative radiodose.

Final step: Is treatment delivery. In this step the patient lies on a couch of the gamma knife,the stereotactic frame is attached to a collimator helmet. Radiation is delivered only when the outer and inner collimators are aligned. The delivery of radiation itself is silent and painless. No general anesthesia is needed and the patient can be managed as if he has undergone a daycare procedure.

Role of stereotactic radiosurgery in the management of acoustic schwannoma:

Radiosurgery is very useful in the management of acoustic schwannoma of less than 3 cm in diameter. This procedure is minimally invasive with negligible facial / trigeminal nerve morbidity. Hearing is also preserved in these patients. NF 2 tumors respond less well to all treatment modalities including radiosurgery.

Role of radiosurgery in the management of skull base meningiomas:

Radiosurgery can be used as an adjunct to open surgery in the management of skull base meningiomas. It is not commonly used as a primary treatment modality because meningiomas are slow growing tumors and by the time they become symptomatic they would have enlarged to a size considerably more than 3 cms which is the treatment limit for radiosurgery.

Role of radiosurgery in glomus jugulare tumors:

The thrombo - obliterative effect of radiosurgery is really useful in the management of vascular tumors like glomus jugulare.

Limitations of stereotactic radiosurgery:

1. The machine itself is designed for cranial disease and hence is limited for intracranial and skull base lesions.

2. The design limitations of the knife makes it really unsuitable for use in lesions of neck.

3. Ideal targets are usually less than 3 cms

Role of radiosurgery in otolaryngology:

1. Stereotactic radiosurgery has been found to be useful in the management of vestibular schwannomas.

2. It can be used to treat skull base tumors like meningiomas.

3. Glomus jugulare tumors can be ideally managed by radiosurgery

Advantages of radiosurgery:

1. It is minimally invasive.

2. Cranial nerves are generally spared leading to preservation of hearing and trigeminal / facial nerve functions

3. No anesthesia is needed

4. Risk of malignancy is really low

Concerns expressed about radiosurgery:

1. Long term follow up is needed.

2. Remote possibility of radiation induced malignancy

3. Causes peritumoral scarring making future surgeries really difficult

Bone anchored Hearing Aid (BAHA)

Introduction: Bone anchored hearing aids (BAHA) are implantable hearing aids that can be used to treat hearing loss of a severe magnitude. This device works directly by stimulating the inner ear via bone conduction. It has been in use from 1977 in Europe. It got approved by the FDA only in 1996.

Indications for use of BAHA:

1. Bilateral canal atresia is an absolute indication for the use of BAHA. This is because canal atresia prevents insertion of ear mould for an air conduction aid.

2. In chronic ear infections when insertion of ear moulds is a problem.

3. Unilateral deafness which cannot benefit from use of regular hearing aids.

Components of BAHA:

BAHA has 3 components. They are :

1. Titanium screw that becomes integrated with the skull bone behind the ear.

2. Titanium abutment is fitted to the titanium screw which is already integrated to the skull bone.

3. Ear level sound vibrator.

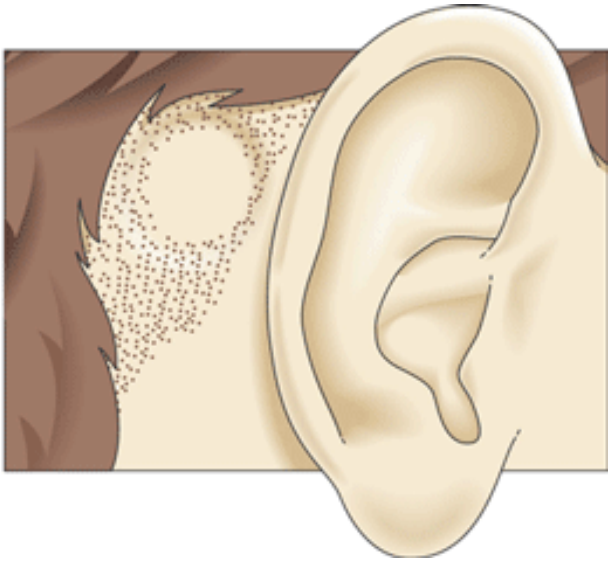


Diagram of BAHA

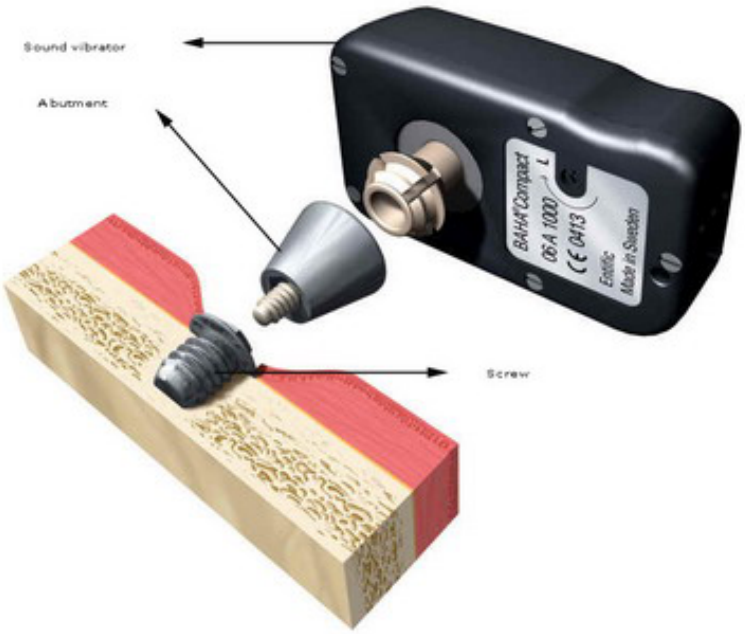


Figure showing components of BAHA

Requirements for BAHA implant: The prime requirement for a successful BAHA implant is that the patient should have adequate bone conduction thresholds. It has been suggested that bone conduction threshold should be atleast 45dB for effective functioning of BAHA. Preopertaive speech audiometry should be performed in all patients before BAHA implant.

Implantation procedure:

BAHA implantation is a surgical procedure. Surgery is performed under local / general anesthesia. It is a relatively simple surgical procedure. The bone posterio-superior to the ear canal is usually of sufficient thickenss over the age of three to take an implant, and allow osseointegration. In adults mostly a single stage procedure is preferred.

In this procedure bone over the skull just postero superior to the ear canal is drilled and the titanium screw is inserted into it. Three month period is allowed to elapse for osseointegration to take place. Abutment is introduced after the osseointegration is complete. The ear level sound vibrator can be attached to the abutment.

Complications of BAHA insertion :

1. Infection

2. Crusting

3. Screw falling out

How BAHA works: It works by by taking the sound from the outside and transmitting it to the inner ear through the bone. This bypasses the ear canal and the middle ear.

BAHA care:

1. Clean the area around the abutment DAILY: Washing your hair will soften any crust. Use the supplied Entific soft cleaning brush and gently wipe the bristles against the side of the abutment, not the skin. Remove any debris around or inside the abutment. Antibacterial soap is recommended. Dry the area gently.

2. Do not allow hair to wrap itself around the abutment.

3. Do not keep hot air from a hair dryer on the abutment for a long period.

4. No hair will grow under the processor.

5. Whenever strong chemicals, such as hair dying solutions, are being applied to your hair, please cover the abutment and skin graft site with plastic to protect your skin and the abutment from the chemicals. When exposed to strong chemicals, the skin surrounding the abutment may become red, swollen, infected, or burned.

6. BAHA should be removed before undergoing MRI imaging.

7. For best benefit it should be worn througout the day.

8. The processor will whistle when touched or when it comes into contact with other objects. Whistling can be reduced by simply repositioning the processor.

9. During windy conditions outdoors, the directional microphones may pick up wind sounds. Simply rotate the processor on the abutment 90 degrees or until the wind sound stops.

Recent nomenclature changes in the classification of CSOM

Introduction: Chronic suppurative otitis media, its classification, and definition has undergone changes. Chronic suppurative otitis media has been rechristened to chronic otitis media. The term chronic otitis media implies a permanent abnormality of the pars tensa / pars flaccida as a result of acute otitis media, negative middle ear pressure or otitis media with effusion.
Chronic otitis media simply does not mean accumulation of pus in the middle ear cavity. It can be subdivided into active chronic otitis media (active com) and inactive chronic otitis media (inactive com).

Active COM: In this condition there is inflammation of middle ear mucosa associated with accumulation of pus. There may also be associated mastoiditis. Active COM can be subdivided into active mucosal COM and active squamosal COM.

Active mucosal COM:

Ear drum in these patients will be perforated. The middle ear mucosa may undergo polypoidal changes causing "aural polypi". It is also important to realize that inflammatory changes in this disorder is not confined to the middle ear alone, the whole of the middle ear cleft is involved. Simple closure of the perforation without removal of infected middle ear mucosa and granulations from the mastoid cavity is fraught with failure to control the disease.

Active mucosal COM is often associated with resorption of parts or whole of ossicular chain. This could be due to resorptive osteitis. The ossicles affected typically show hyperemia with proliferation of capillaries and prominent histiocytes. Long process of incus gets eroded commonly, followed by stapes crurae, body of incus and manubrium in that order.

Active squamous COM: This condition is otherwise known as unsafe ear or cholesteatoma. This condition is commonly associated with retraction of pars flaccida / tensa that has retained squamous epithelial debris. There is also associated inflammation of middle ear mucosa, production of pus, and erosion of ossicles. This condition is commonly associated with intracranial complications.

Inactive Chronic otitis media: In this condition the middle ear mucosa is relatively healthy. The mastoid cavity also appear healthy. These patients may slip into active phase rather easily because of the existing pathology. Inactive chronic otitis media can further be subdivided into Inactive mucosal chronic otitis media and Active squamous chronic otitis media.

Inactive mucosal chronic otitis media: This condition is always associated with dry perforation of the ear drum. There is permanent perforation of the pars tensa, but the middle ear and mastoid mucosa are not inflammed. The drum remnant around the perforation is always healthy. The rim of the perforation is thickened due to proliferation of fibrous tissue. Squamous epithelial cells from the external auditory canal does not migrate into the middle ear cavity in this stage because the annulus of the ear drum is intact and it prevents this migration. These patients benefit from myringoplasty.

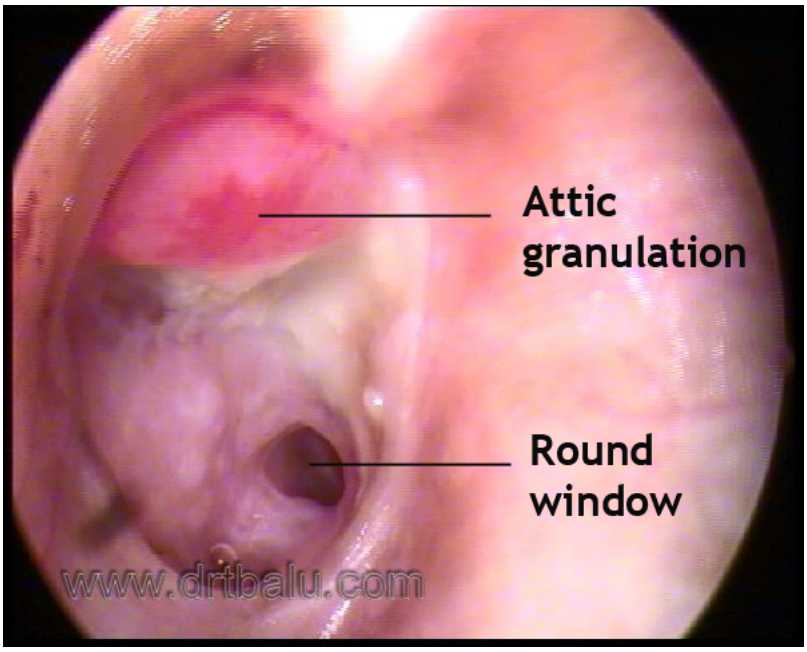


Figure showing attic granulation

Figure showing active chronic suppurative otitis media.

Inactive squamous epithelial chronic otitis media: These include retraction pockets, atelectasis and epidermization. Negative middle ear pressure can cause retraction of tympanic membrane. A retraction pocket consists of an invagination into the middle ear space of part of the ear drum. These retraction pockets may be fixed when it is adherent to structures in the middle ear or free when it can move freely medially or laterally depending on the state of inflation of the middle ear. “Epidermization” is a more advanced type of retraction and it refers to replacement of middle ear mucosa by keratinizing squamous epithelium without retention of keratin debris. The area of epidermization may involve part or all of the middle ear cavity. Epidermization often remain quiescent and does not progress to cholesteatoma or active suppuration. So epidermization per se is not an indication for surgical intervention.

Healed chronic otitis media: In this stage the perforated ear drum has managed to heal itself. Loss of lamina propria or the tympanic membrane due to atrophy or failure of complete healing leads to a ‘dimeric’ membrane that consists of epidermis and mucosa only. Such thin membrane is more prone to retraction if there is negative middle ear pressuree.

Tympanoslcerosis is also another form of healed ear drum. It refers to hyaline deposits of acellular material visible as whitish plaques in the tympanic membrane or as white nodular deposits in the sub-mucosal layers of the middle ear on otoscopy. Tympanosclerosis is the end result of a healing process in which collagen in fibrous tissue hyalinizes, loses its structure and become fused into a homogenous mass. Calcification and ossification may occur to a variable extent.

Figure showing dry central perforation of ear drum

Autophony & current trends in its management

Definition: Autophony literally means hearing one's voice in one's own ear. This condition is commonly caused by a persistently open eustachean tube.

Pathophysiology: In Autophony air flows into the middle ear cavity from the nasopharynx on a continuing basis through a persistantly open eustachean tube causing a roaring noise when ever the patient takes a breath. These patients irked by hearing their own voice in the ear, starts to speak in a whisper. These patients become so upset psychologically, they turn recluse and become depressed.

The exact mechanism causing autophony still remains unknown. CT scan in these patients show atrophy of soft tissues surrounding the tube. The possibility of this atrophy keeping the eustachean tube open should be considered.

Peculiar features of autophony is that it gets releived when the patient lies on his back or when bending at the waist. These two manouvers close the eustachean tube. These patients also have a peculiar habit of sniffing frequently in an attempt to close the pharyngeal end of eustachean tube.

Etiology:

Possible etiological factors causing autophony include:

1. Weight loss

2. Autoimmune disorders like Wegener's granuloma, Bell's palsy, Crohn's disease, Meniere's disease.

How these autoimmune conditions cause autophony is still not clear. About 1/3 of patients with autophony have autoimmune disorder.

Females are commonly affected than males. Unilateral autophony is common than bilateral involvement.

Investigations:

1. Impedance auditometry

2. Sonotubometry

Treatment:

The aim of treatment is directed towards reducing the size of the eustachean tube. It is hence possible to reduce the size of eustachean tube by inserting silicone tubing of 1mm size through the middle ear end of eustachean tube past the isthumus.

If the eustachean tube opening is very large then silicone block can be inserted via the middle ear end of eustachean tube. After this procedure it is better to insert a ventilation tube to prevent fluid accumulation in the middle ear cavity.

Microdebrider eustachean tuboplasty: Before performing tuboplasty, CT scan of paranasal sinuses must be done. If there is evidence of sinusitis then FESS surgery should be combined with tuboplasty. It is always better to perform tuboplasty before sinus surgery to ensure dry field.

The whole surgical procedure can be performed under local anesthesia. Topical anesthesia is provided by placing cotton pledgets dipped in 4% xylocaine with 1 in 10,000 units adrenaline. Infiltrative anesthesia is provided by injecting 1% xylocaine with 1 in 10,0000 units adrenaline. This solution is injected along the entire posterior eustachean tube cushion. Injections are also given along the superior portion of the anterior cushion.

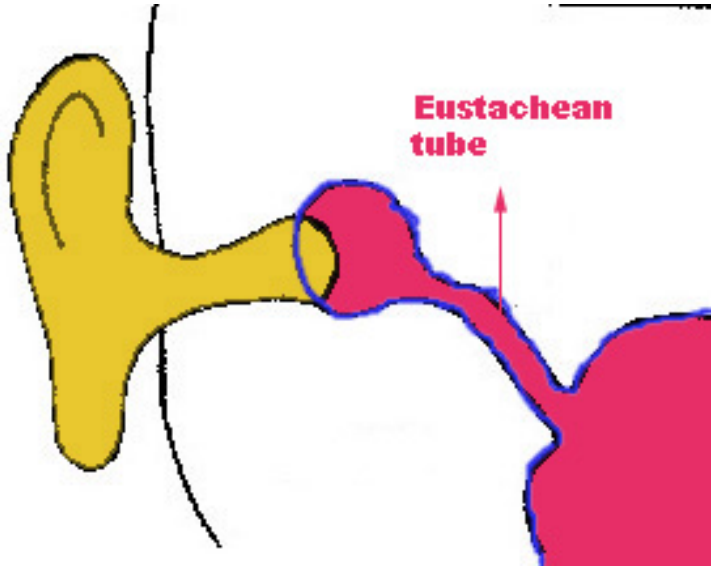


Diagram showing anatomy of eustachean tube

Microdebrider is used to remove excessive soft tissue from the posterior eustachean tube cushion. Tissure removal is started in the midportion of the posterior cushion. Injury to the mucosa over the anterior cushion should be avoided, as it could cause scarring. The cutting surface of the debrider should always be directed towards the posterior cushion. Debriding is continued till the valvular area is reached i.e. the junction between the anterior and posterior cushions.

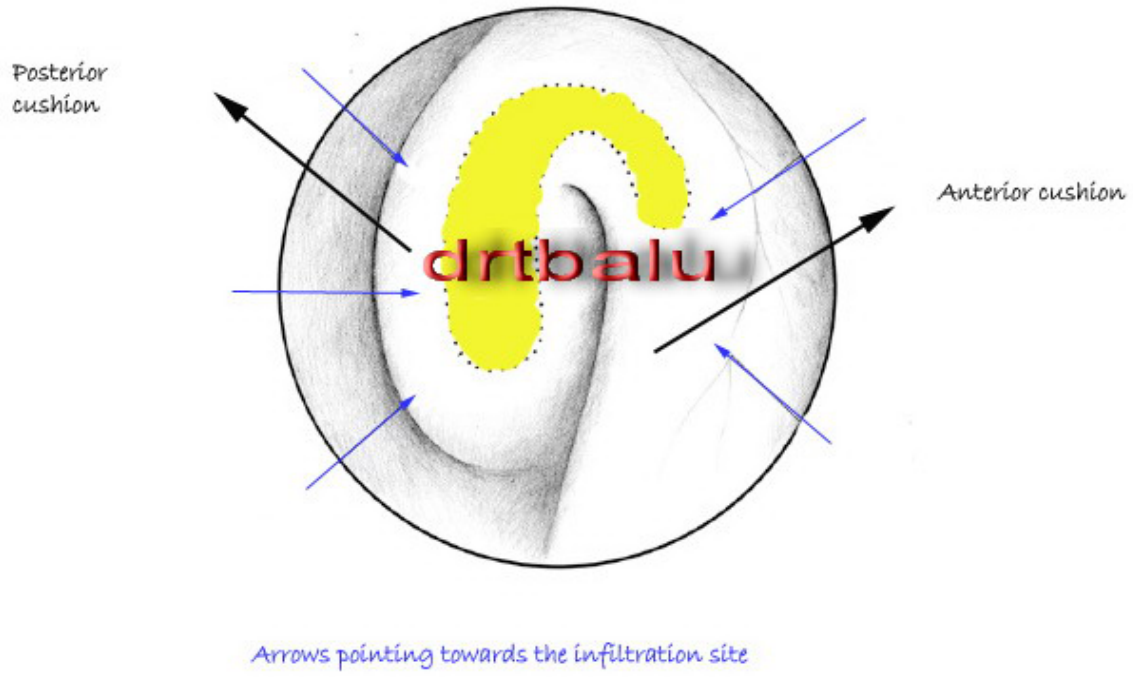


Figure showing sites of infiltration before tuboplasty

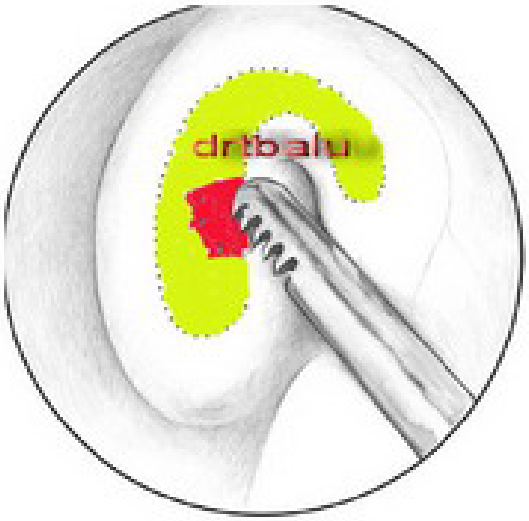


Figure showing microdebrider being used to perform tuboplasty

* Caution: All soft tissue removal should be superficial to the tubal cartilage to prevent damage to the carotid artery. *

Lasers can be used to perform Eustachean tuboplasty.

Role of keel and stents in laryngotracheal disorders

Introduction: Keels and stents are used to prevent adhesion formation in the laryngotracheal tree. These keels and stents also keep the laryngotracheal tree open after surgical procedures involving these structures.

Keel: Keels come in different sizes. These are used to prevent adhesions, restenosis and web formation. This is particularly useful following glottic surgeries. It keeps both the anterior and posterior commissures separated thereby preventing adhesions. These keels are made of teflon, silastic or titanium. These materials are rather inert and do not irritate the soft tissues.

Keels should be long enough to extend from the crico thyroid membrane to 2 - 3 mm above the posterior commissure of the vocal folds. Superior portion of the stent should make a 120 degree angle to minimize granulation tissue formation at the level of posterior commissure / petiole of epiglottis. Keels can be placed endoscopically or through cricothyroidotomy. It is held in position by placing heavy sutures through the cricothyroid membrane. Ideally, these keels are left in place atleast for a period of 4 - 6 weeks. Removal of keel should ideally be performed under general anesthesia.

Stents:

Indications for the use of internal stenting are as follows:

1. Maintenance of the lumen after reconstruction in the absence of inadequate cartilagenous support.

2. Support for cartialge / bone grafts

3. To separate opposing raw mucosal surfaces during the healing porcess

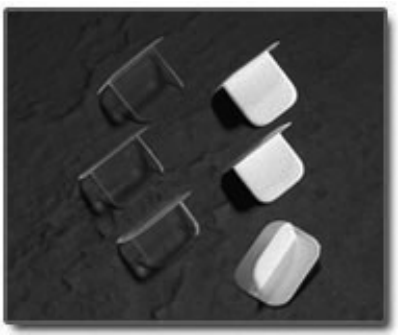


Figure showing various laryngeal keels

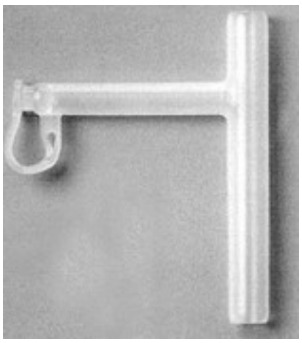


Figure showing Montgomery T Tube

** Note: If the stent is used to only allow mucosal healing / to allow graft take, it can be removed within 2 - 3 weeks. Prolonged use of stents i.e for more than a year is advisible only when there is grossly deficient laryngeal framework. Here in it is ideal for the scar tissue to develop around the stent.*

Types of stents used:

Firm stents are used when splinting is required.

Solid stents are used if aspiration is a problem.

Soft hollow stents are used when use of voice is desirable.

Aboulker stent: This is one of the oldest stents to be developed. It was first introduced in 1960. This stent is commonly used to stabilize tissues following laryngotracheal reconstruction in children with subglottic stenosis. This stent is shaped like a cigar and is made of teflon. Major advantage if this stent is that it causes very little irritation. The base of epiglottis can be irritated with formation of granulation tissue.

Montgomery stent: This stent is made of silicone. It has a long central lumen and a smaller lumen projecting from the side of the stent at an angle of 90 degrees. This stent was first developed in 1965. This stent is used to stent the larynx and trachea after reconstruction for areas of malacia and stenosis. This stent is soft and can be retained for atleast 1 year. Its main advantage is that it helps the patient to speak. It is more prone to crusting. It is contraindicated in children under the age of 2 as its lumen size is too narrow, and can be easily blocked.

Silastic sheet / Swiss roll: This was first used by Evan's in 1977 for laryngotracheoplasty. The silastic sheet is rolled up and inserted into the larynx and upper trachea. It is stabilized in place by a stay suture. This roll has a constant tendency to unravel, thus producing steady pressure on the mucosa. This pressure has a beneficial effect by obliterating dead space allowing mucosa to regenerate.

Metal stents: These stents are easy to use in distal trachea and bronchi. They are enmeshed and hence do not obstruct the bronchi. These stents include Palmaz and Streker stents. These stents are introduced via a bronchoscope.

Complications of stents:

1. Local infections

2. Mucosal ulceration

3. Granulation tissue formation

4. Stenosis

Endoscopic Hypophysectomy

History:

1980's heralded the nasal endoscope. It soon became an important tool in the armamentorium of the otolaryngologist. It really took them to areas which were previously beyond their realms of imagination. Access to these areas soon became reality. The illumination and visualization provided by the nasal endoscope was simple unparalleled. Simultaneously CT scan study of para nasal sinuses also gained in popularity, enabling the surgeon to have an exact understanding of the anatomy of this crucial area. Soon the "neglected sinus" (adage for sphenoid sinus) became the most studied sinus. In fact it threw up an important gateway to access pituitary gland.

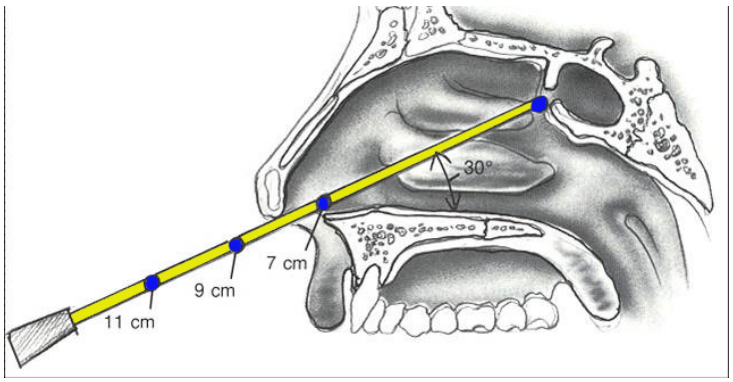


Diagram illustrating the approximate distance of sphenoid sinus from anterior nares

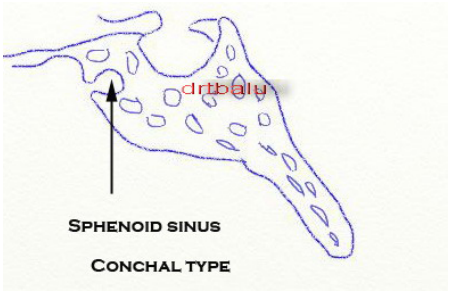
Surgical anatomy:

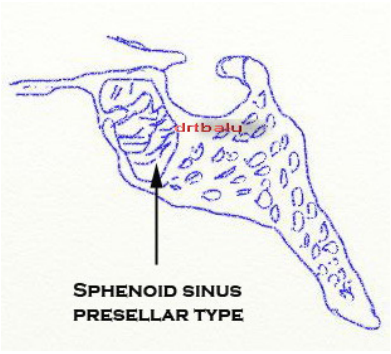
A study of surgical anatomy of sphenoid sinus is a must for successful completion of this surgical procedure. Depending on the extent of pneumatization sphenoid sinus has been classified into three types i.e. conchal, presellar and sellar.

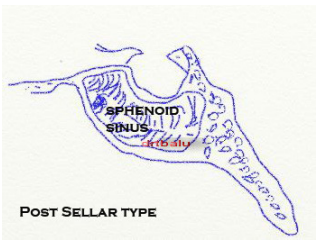
Conchal type: In this type the area below the sella is a solid block of bone without an air cavity. This type is common in children under the age of 12 because pneumatization begins only after the age of 12.

Presellar type: In this type the air cavity does not penetrate beyond the coronal plane defined by the anterior sellar wall.

Sellar type: In this type the air cavity extends into the body of the sphenoid below the sella and may extend as far posteriorly as the clivus. This type is commonly seen in 85% of individuals.







The sphenoid ostium is located in the sphenoethmoidal recess. It can be commonly seen medial to the superior turbinate about 1.5 cms superior to the posterior choana. In fact it lies just a few millimeters below the cribriform plate.

The right and left sphenoidal sinus is separated by a intersinus septum. The position and attachement of this septum is highly variable.

Possible variations of intersinus septum are as follows:

1. A single midline intersinus septum extending on to the anterior wall of sella.

2. Multiple incomplete septae may be seen

3. Accessory septa may be present. These could be seen terminating on to the carotid canal or optic nerve.

Lateral wall of sphenoid sinus: is related to the cavernous sinus. This sinus is formed by splitting of the dura. It extends from the orbital apex to the posterior clinoid process. Cavernous sinus contains very delicate venous channels, cavernous part of internal carotid artery, 3rd, 4th and 6th cranial nerves. It also contains some amount of fatty tissue.

The prominence of internal carotid artery is the postero lateral aspect of the lateral wall of sphenoid sinus. This prominence can be well identified in pneumatized sphenoid bones. On the antero superior aspect of the lateral wall of sphenoid sinus is seen the bulge formed by the underlying optic nerve. These two prominences are separated by a small dimple known as the opticocarotid recess. The optic nerve and internal carotid artery is separated from the sphenoid sinus by a very thin piece of bone. Bone dehiscence is also common in this area.

In well pneumatized sphenoid sinus, the pterygoid canal and a segment of maxillary division of trigeminal nerve could be identified in the lateral recess of the sphenoid sinus.

The roof of the sphenoid (planum sphenoidale) anteriorly is continuous with the roof of ethmoidal sinus. At the junction of the roof and posterior wall of sphenoid the bone is thickened to form the tuberculum sella. Inferior to the tuberculum sella on the posterior wall is the sella turcica. It forms a bulge in the midline. The bone over the sella could be 0.5 - 1 mm thick. This may get thinner inferiorly. It is hence easy to breech the sella in this tinnest part. This area can be easily identified by a bluish tinge of the dura which is visible through the thin bony covering.

The main portion of the pituitary gland lies in the sella turcica and is connected to the brain by a stalk known as the infundibulum. In front of the infundibulum, the upper aspect of the gland is related directly to pia archnoid. The subarachnoid space hence extends below the diaphragm. This anatomy should be borne in mind before opening up the pituitary through the sphenoid sinus. The pituitary gland is related superiorly to the optic chiasma and below to intercavernous sinus. Inadvertant trauma to this sinus could cause troublesome bleeding, hence care should be taken to avoid this structure.

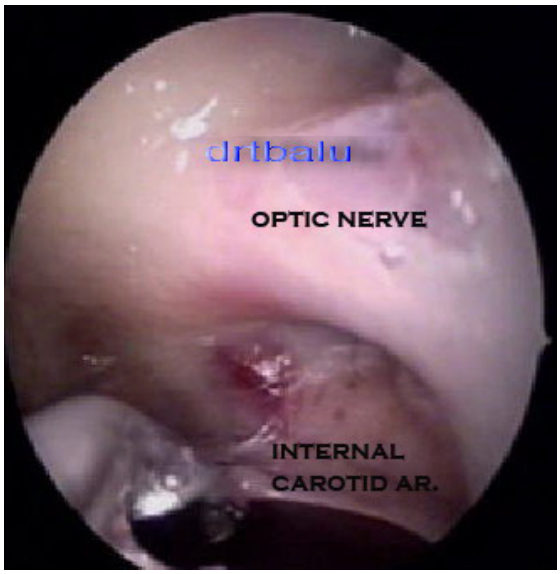


Figure showing endoscopic view of sphenoid sinus

Indications for endoscopic hypophysectomy:

Secretory / Nonsecretory pituitary tumors. Non secretory tumors reach a large size before becoming symptomatic. These patients present with ocular symptoms due to pressure over optic chiasma, oculomotor nerve dysfunction due to involvement of cavernous sinus.

Most prolactin secreting pituitary adenomas respond well to bromocriptine, hence surgery can be withheld in these patients.

Tumors secreting growth / adrenocorticotrophic hormones are indications for early surgery to achieve endocrinological cure.

Patients with suspected aneuryms should undergo angiography.

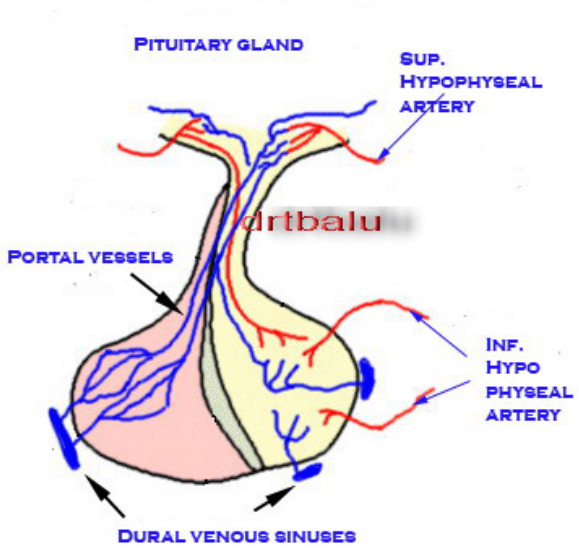


Diagram illustrating pituitary gland anatomy

Surgical technique:

Nasal cavities are decongested by use of nasal packs mixed with 4% xylocaine with 1 in 10,000 units adrenaline.

This surgery is performed under general anesthesia.

The patient is positioned supine with head elevated to 30 degrees. Patient's bladder is catheterised to monitor urinary output in the post op period.

Nasal endoscopic examination is performed using 0 degree and 30 degrees nasal endoscope. The sphenoid ostium is identified in the sphenoethmoidal recess on both sides. Surgery is usually started on the side where the sphenoid ostium is better visualized. The sphenoid ostium is widened inferiroly and medially till the floor of the sphenoid sinus is reached. The septal branch of sphenopalatine foramen if encountered is cauterized using bipolar cautery. The sphenoidotomy is extended to the opposite side by removing the rostrum of sphenoid. About 1 cm of the posterior part of vomer is removed with reverse cutting forceps.

After this step both ENT and Neurosurgeon work as a team. The neurosurgeon applies suction through left nostril to ensure that the operating field is clear. The bulges formed by the internal carotid artery and optic nerve are identified. Care must be taken while the intersinus septum is removed because it could be directly attached to the internal carotid artery, hence true cut instruments should be used.

A ball probe is used to access the thickness of the anterior wall of the sella, fracturing it at the thinnest portion. A kerrison punch is used to widen the opening. Dural bleeding is controlled using bipolar cautery. A cruciate incision is made. The vertical limb of the incision should not extend too superiorly to avoid subarachnoid space. The intercavernous sinus should be avoided inferiorly. Since most of these tumors are gelatinous and semisolid in nature, they can be easily sucked out by using a suction. Blunt ring curettes are used to remove the tumor completely.

The tumor removal is done in a systematic manner. It is usually started from the floor, then laterally and finally the supra sella component if any is attended to. The nasal cavity is packed with Merocel.

Post operative care:

The patient is kept in surgical ICU for 24 hours. Urinary output is monitored. Adequate doses of antibiotics are used parentally.

Complications:

1. CSF leak

2. Diabetes insipidus

3. Intrasellar hematoma

4. Death due to trauma to internal carotid artery

5. Blindness due to damage to optic nerve

CSF leak: This is one of the commonest intraoperative complication. The usual cause is trauma to the diaphragma with instruments like curette, forceps etc. This area is very thin and highly susceptible to trauma. When csf leak is identified intraoperatively, the defect should be identified and repaired with intrasellar placement of abdominal fat and fibrin glue. Lumbar drainage is performed for 5 days. Minor weeping defects of dura can be expected to heal on its own.

Meningitis: This is an uncommon complication following surgery. Organisms involved include staph aureus, strep. pneumonia etc. Broad spectrum antibiotics should be used to manage these patients.

Diabetes insipidus: This complication may be transient / permanent. Commonly this condition is transient in nature. These patients should be managed with intranasal administration of desmopressin. Permanent diabetes insipidus may be caused by damage to pituitray stalk. during surgery.

Bleeding: Intraoperative bleeding may be caused due to inadequate nasal decongestion, excessive stripping of sphenoid mucosa, trauma to cavernous sinus, trauma to internal carotid artery. Persistent post op bleeding could be caused due to trauma to sphenopalatine artery and its branches.

Intrasellar hematoma: Transient / permanent loss of vision may be caused due to intrasellar hematoma / or due to direct damage to optic chiasma. In cases of intrasellar hematoma, CT scan should be done to clinch the diagnosis. Immediate evacuation of heamatoma should be done.

Contraindications:

1. Poor general condition of patient

2. Conchal type of sphenoid pneumatization

3. Prolactinomas

Endoscopic surgery of orbit

Introduction:

With the advent of use of endoscopes in nasal surgeries, its use for other surgical modalities are on the increase. The major advantage of using the endoscope is its excellent resolution, image quality, improved visualisation of key areas.

Kennedy etal first described endoscopic orbital decompression during the early 1990's. Since then endoscopes have been widely used in orbital decompression procedures for managing Proptosis due to Graves disease (Grave's orbitopathy). It is also being increasingly used for optic nerve decompresssion procedures.

Endoscopic orbital decompression:

In this procedure the whole medial wall of orbit along with the medial portion of the orbital floor is removed. The use of endoscope allows for unmatched visualization of various critical anatomical regions like skull base, and orbital apex. Major advantage is the avoidance of skin incisions.

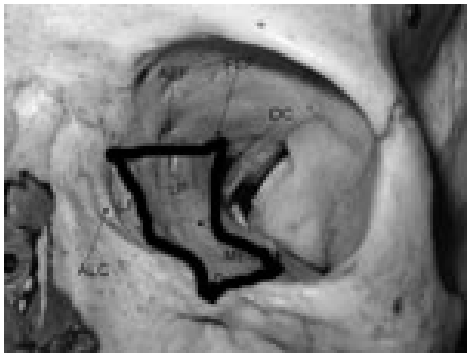


Figure showing the areas of bone removed in orbital decompression

Endoscope

Procedure:

This procedure is performed under general anesthesia. The use of image guidance system helps in avoiding complications and injury to vital structures.

1. The nasal mucosa is decongested using cotton pledgets soaked in 4% xylocaine with 1 in 100000 units adrenaline.

2. Incision is sited just behind the maxillary line, and through the uncinate process. The whole of the uncinate process is medialized and removed.

Image showing Lamina papyracea being curretted out

Removal of uncinate process enables better visualization of the maxillary sinus ostium. The ostium is opened widely up to the floor of the orbit superiorly, the wall of the maxillary sinus posteriorly, and the inferior turbinate inferiorly. Care is taken not to extend the maxillary sinus ostium anteriroly beyond the frontal process of maxilla to prevent injury to the naso lacrimal duct. A 30 degree endoscope is used to visualize the infra orbital nerve through the maxillary sinus ostium as the nerve courses along the floor of the orbit.
Now endoscopic sphenoidotomy is performed. After this process the anterior and posterior ethmoidal arteries can be identified as it courses through the skull base. The middle turbinate is removed to enable optimal visualization of the medial orbital wall. An image guidance system may be used at this point for intranasal navigation.

After complete exposure of the medial orbital wall, a curet is used to penetrate the thin bone of lamina papyracea. The thin bone is carefully elevated exposing the underlying periorbita. Bone removal is proceeded superiorly towards the roof of ethmoid, inferiorly up to the orbital floor and anteriorly up to the maxillary line. Bone over the frontal recess area is left intact, this is done to prevent prolapsing orbital fat from obstructing frontal sinus drainage.

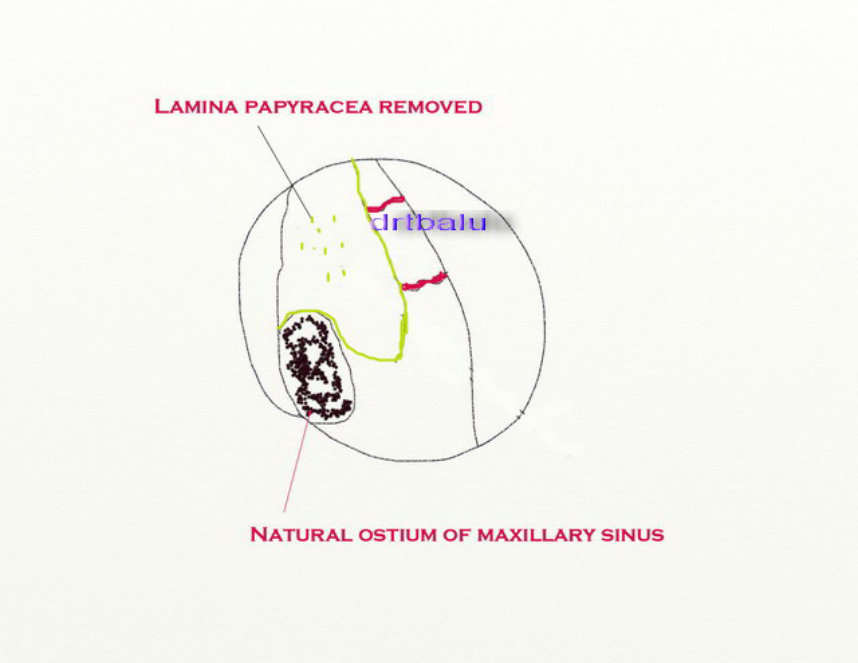


Figure showing lamina papyracea after removal

Removal of orbital floor could be the most demanding task. Only that portion of the floor of the orbit medial to the infraorbital nerve is removed. A spoon curet could be used for this purpose. A sickle knife may be used to open up the periorbita. The periorbital incision is started at the posterior limit of decompression and brought anteriorly in order to prevent orbital fat from obscuring the vision. Parallel incisions are made along the ethmoid roof and orbital floor. To reduce the risk of diplopia post operatively a sling of fascia overlying the medial rectus may be preserved. On completion of this procedure fat could be seen prolapsing into the nose and maxillary sinus.

Nasal packing should be avoided to enable maximum decompression.

Complications:

1. Diplopia

2. Post operative bleeding

3. Epiphora due to injury to nasolacrimal duct

Endoscopic optic nerve decompression:

The most common indication for optic nerve decompression is traumatic optic neuropathy. Endoscopic decompression of optic nerve has many advantages, which include excellent visualization, preservation of olfaction, with rapid recovery time. It also has the added advantage of lack of external scars.

Anatomy of optic nerve:

The optic nerve per se can be divided into three segments: intraorbital, intracanalicular, and intracranial. The main goal of optic nerve decompression is to releive the compressive forces within the intracanalicular portion of the nerve. The optic nerve canal is formed by two struts of the lesser wing of sphenoid. This canal carries the optic nerve and ophthalmic artery. Within the optic canal the nerve is ensheathed by three meningeal layers. At the orbital apex is the fibrous annulus of Zinn. This thick fibrous layer is the least expandable portion of the fibrous tissue around the optic nerve. This area has been postulated to be the most susceptible site for pathologic compression of the optic nerve.

Procedure:

Patients are prepared in the same way as for any other orbital surgeries described. A standard sphenoethmoidectomy is performed.

The anterior face of the sphenoid is opened widely, and the bulge of the optic nerve canal is identified along the lateral wall of the sphenoid sinus.

After complete sphenoethmoidectomy, a spoon curette is used to fracture the lamina papyracea approximately 1 cm anterior to the optic canal. The lamina is removed carefully in a posterior direction to expose the annulus of Zinn. When the optic canal is reached the thin lamina is replaced by thick bone of the lesser wing of sphenoid. This bone must be thinned with a diamond burr before removal. It is recommended that the optic sheath is also incised to enable better decompression.

Complications:

1. CSF leak

2. Meningitis

3. Visual decompensation

King Kopetzky syndrome

Introduction:

King Kopetzky syndrome is a condition in which an individual complaints of difficulty in hearing, especially in the presence of back ground noise. Ironically these patients have a normal pure tone audiogram.

Hinchcliffe described this disorder as "Auditory stress disorder". He also coined the term King Koptezky syndrome to describe this disorder to honor Koptetzky who described this disorder in 1948 and King who discussed the etiological factors behind this syndrome in 1954.

Synonyms:

Auditory stress disorder, KK syndrome, Obscure auditory dysfunction, Auditory disability with normal hearing.

Incidence:

KKS is relatively a common condition. It is seen in 5% of patients who attend audiological clinic with problems in hearing.

This syndrome is fairly common in elderly, with a mean age of occurrence of 76.

Etiology:

This condition could be caused by minor cochlear defect associated with psycological causes. These patients also have a high family prevalance of deafness.

Certain authors consider this disorder to be a late manifestation of a dominantly inherited genetic disorder.

Noise exposure has also been postulated as one of the etiological factors of KK syndrome.

Poor central auditory function

Auditory stressful work

Awareness of previous ear disease

Depression

Loneliness

Clinical features:

1. These patients have difficulty in hearing in noisy environment

2. Significant percent of these patients have difficulty in handling group conversations

3. A small percentage 5% of these patients have difficulty in comprehending TV / Radio programmes

Types of KK syndrome:

Etiologically King Kopetzky syndrome has been classified into four types:

1. Middle ear kk syndrome

2. Cochlear kk syndrome

3. Central kk syndrome

4. Psychological kk syndrome

Investigations:

Puretone audiometry: shows a notch in midfrequency range.

Speech audiometry shows low values.

Patients have low speech scores under noisy environments

Management:

1. Stress management

2. Allaying the patient's anxiety

3. Use of hearing aids

4. Counselling

Scoring methodology to assess physical well being of chronically ill patients

Introduction:

It is very difficult to assess the physical well being of chronically ill patients. Chronic illness in this context indicates a chronic ailment with which a patient has to suffer right through his / her life. These illnesses include Malignancies, chronic renal disorders, CNS disorders etc.

Advantages of these scoring systems:

1. It attempts to assess the sense of physical well being of patients.

2. Assesses the adequacy / usefulness of the treatment modality.

3. Helps in the adjusment of drug dosage in chemotherapy.

4. Helps in the assessment of required intensity of palliative care.

Available scoring systems:

There are various scoring systems available. They include:

1. Karnofsky score

2. Zubrod score - This score is commonly used in WHO publications

3. Lansky score - This score is used commonly in children

4. Global assessment of functioning (GAF) score - This method of scoring is used in psychiatry

Karnofsky scoring system: This scoring system is named after Dr David A. Karnofsky, who described the scale with Dr Joseph H. Burchenal in 1949.

This score infact runs from 100 - 0. A score of 100 means perfect health, while a score of 0 means death.

100 - Perfect health

90 - Capable of normal activity, few symptoms or signs of disease

80 - Normal activity with some difficulty, some symptoms or signs

70 - Caring for self, not capable of normal activity or work

60 - Requiring some help, can take care of most personal requirements

50 - Requires help often, requires frequent medical care

40 - Disabled, requires special care and help

30 - Severely disabled, hospital admission indicated but no risk of death

20 - Very ill, urgently requiring admission, requires supportive measures or treatment

10 - Moribund, rapidly progressive fatal disease processes

0 - Death

Zubrod score: Also known as WHO score. Was first published by Oken et al in 1982. This score runs from 0 - 5. 0 indicates perfect health, while 5 denotes death.

0 - Normal health

1 - Symptomatic but completely ambulatory (Restricted in physically strenuous activity but ambulatory and able to carry out work of a light or sedentary nature. For example, light housework, office work)

2 - Symptomatic, <50% in bed during the day (Ambulatory and capable of all self care but unable to carry out any work activities. Up and about more than 50% of waking hours)

3 - Symptomatic, >50% in bed, but not bedbound (Capable of only limited self-care, confined to bed or chair 50% or more of waking hours)

4 - Bedbound (Completely disabled. Cannot carry on any self-care. Totally confined to bed or chair)

5 - Death

Lansky score: This scoring pattern is very useful in assessing the well being of children. They infact present unique problems in the scoring system. This system of scoring was proposed by Lansky etal in 1987. This scoring pattern starts with 100 which is normal for a child, with 0 indicating an unresponsive child.

100 - Fully active, normal

90 - Minor restrictions in strenuous physical activity

80 - Active, but tired more quickly

70 - Greater restriction of play and less time spent in play activity

60 - Up and around, but active play minimal; keeps busy by being involved in quieter activities

50 - Lying around much of the day, but gets dressed; no active playing participates in all quiet play and activities

40 - Mainly in bed; participates in quiet activities

30 - Bedbound; needing assistance even for quiet play

20 - Sleeping often; play entirely limited to very passive activities

10 - Doesn't play; does not get out of bed

0 - Unresponsive

Spasmodic dysphonia current management trends

Introduction:

Spasmodic dysphonia is commonly of adductor type. This is infact a focal form of adult onset laryngeal dystonia
caused by excessive adduction due to adductor spasm of vocal folds.

Character of voice in these patients:

Voice in these patients is strained and husky. It shows tremors and involuntary pitch breaks. The quality of voice in
these patients deteriorates during stressful speaking conditions. This voice causes psychologically a negative impact on
the patient's quality of life leading to social isolation.

Etiopathogenesis:

This condition is assumed to be caused by a chronic neurologic disorder of central motor processing, causing action induced muscle
spasms of larynx.

Management:

This type of dysphonia is highly resistant to voice therapy.

Various surgical modalities like recurrent laryngeal nerve section and Type II thyroplasty have high failure rates. These surgical procedures
are fraught with increased incidence of complications.

Botox (Botulinum toxin) injections into the thyroarytenoid muscle provides variable relief with no side effects. Voice improvement lasts only
for a limited period of time lasting for weeks - months. Botox causes chemical denervation of thyroarytenoid muscle by interfering with release
of acetyl choline at motor end plates.

Laser thyroarytenoid myoneurectomy:

This surgery is performed under general anesthesia.

Co2 laser with 10 watts intensity is used in continuous mode, slightly defocused.

Ventricular bands are partially resected on both sides exposing the vocal cords completely.

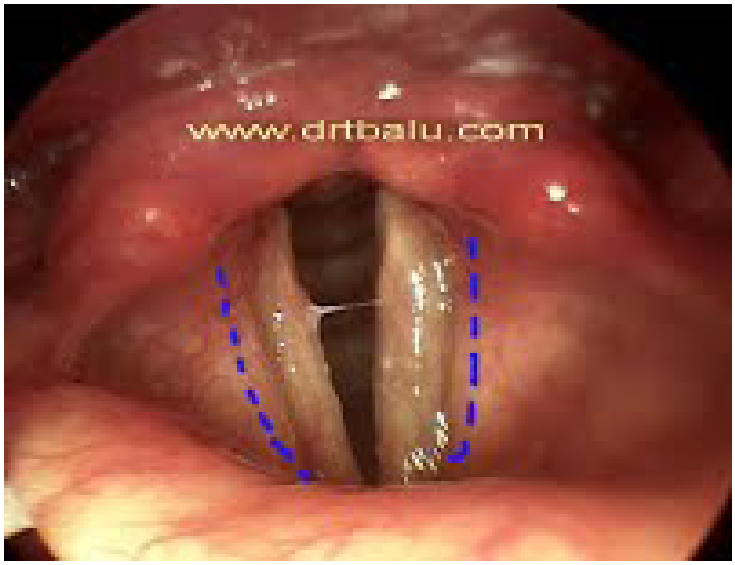


Figure showing incision lines to excise the ventricular bands

The middle and posterior third of thryoarytenoid muscles are excised / vaporized (if laser is used).

Care should be taken to prevent damage to vocalis muscles.

Figure showing thryroarytenoid muscles excised

Posterior sinus of middle ear

Posterior sinus of middle ear cavity is one of the recently identified anatomical sinus inside the middle ear cavity.
Serial temporal bone dissections have shown that it is present in nearly 90% of dissected bones.

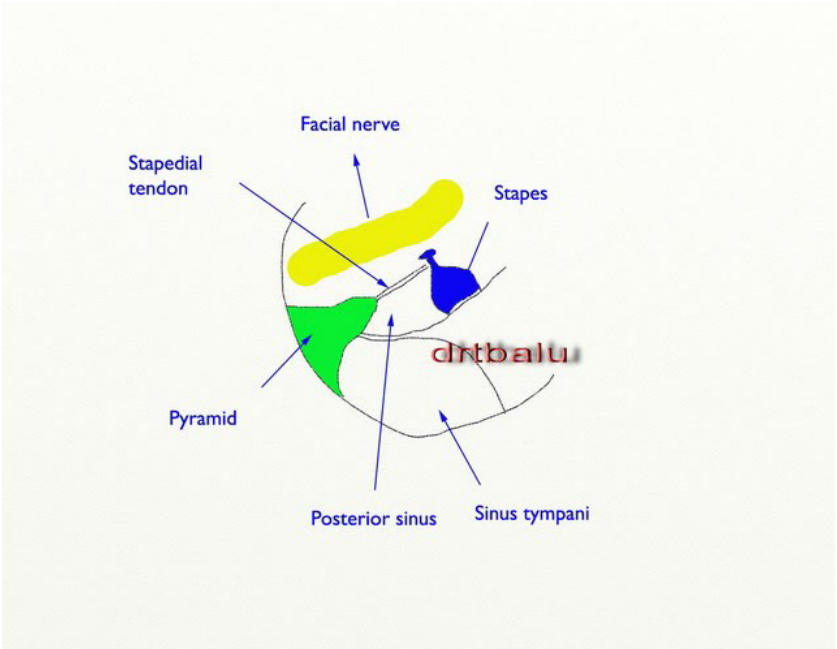
Position: It lies just posterior to the oval window.

Depth: 1mm or less
Width: 1.5 mm or less

In nearly 60% of dissected specimen a ridge of bone arising from the floor of middle ear cavity separates it from sinus tympani.

In 8% of dissected specimen, the sinus tympani and posterior sinus merged together to form one confluent sinus.

It has been demonstrated that cholesteatoma / granulation tissue may lie within this sinus making removal difficult leading on to
residual disease.
Retraction pockets may also occur close to this area.



Laryngopharyngeal reflux

Laryngopharyngeal reflux is caused due to retrograde flow of gastric contents into laryngopharynx.

This condition is related to GERD (Gastric oesophageal reflux disease). In fact it is a common extra oesophageal manifestation of GERD.

Clinical manifestations:

Voice change
Excessive throat clearing
Copious amount of mucous
Feeling of lump in the throat
Difficulty in swallowing
Heart burn
Chronic cough
Vague discomfort in the throat

To help in the diagnosis of laryngopharyngeal reflux two score charts have been devised:

1. Reflux symptom index

2. Reflux finding score.

Reflux symptom index: Suspected patients are given a questionnaire to answer. It contains about 9 questions. Patient is supposed to award scores according to their symptoms.

Reflux symptom index chart:

Within last month how did the following problems affect you ?

1. Hoarseness of voice / voice problems : scores 0 - 5. 0 = No problem 5 = severe problem

2. Clearing your throat: Scores 0 - 5

3. Excess throat mucous / post nasal drip: scores 0 - 5

4. Difficulty in swallowing food / liquids / pills: scores 0-5

5. Cough after eating / lying down: scores 0-5

6. Breathing difficulty / choking: scores 0-5

7. Annoying cough: Scores 0-5

8. Sticky sensation in throat / lump in throat: Scores 0-5

9. Heart burn / chest pain: scores 0-5

Reflux symptom index score of more than 13 indicates laryngopharyngeal reflux.

Reflux finding score:

This scoring is prepared by the surgeon after performing a laryngeal examination.

1. Subglottic oedema: 0 - absent, 2 - present.

2. Ventricular obliteration: 2 - partial, 4 - complete

3. Erythema / Hyperemia: 2 - arytenoids involved, 4 - diffuse

4. Vocal fold oedema: 1 - mild, 2 - moderate, 3 - severe, 4 - polypoidal

5. Diffuse laryngeal oedema: 1 - mild, 2 - moderate, 3 - severe, 4 - obstruction

6. Posterior commissure hypertrophy: 1 - mild, 2 - moderate, 3 - severe and 4 - obstruction.

7. Granuloma / Granulation: 0 - absent, 2 - present

8. Thick mucous: 0 - absent, 2 - present.

A score of 7 indicates possible presence of laryngopharyngeal reflux.

Pepsin Immunoassay:

Detection of pepsin in the throat sputum of patients indicates the presence of laryngopharyngeal reflux.

It is 100% sensitive, and 90% specific.

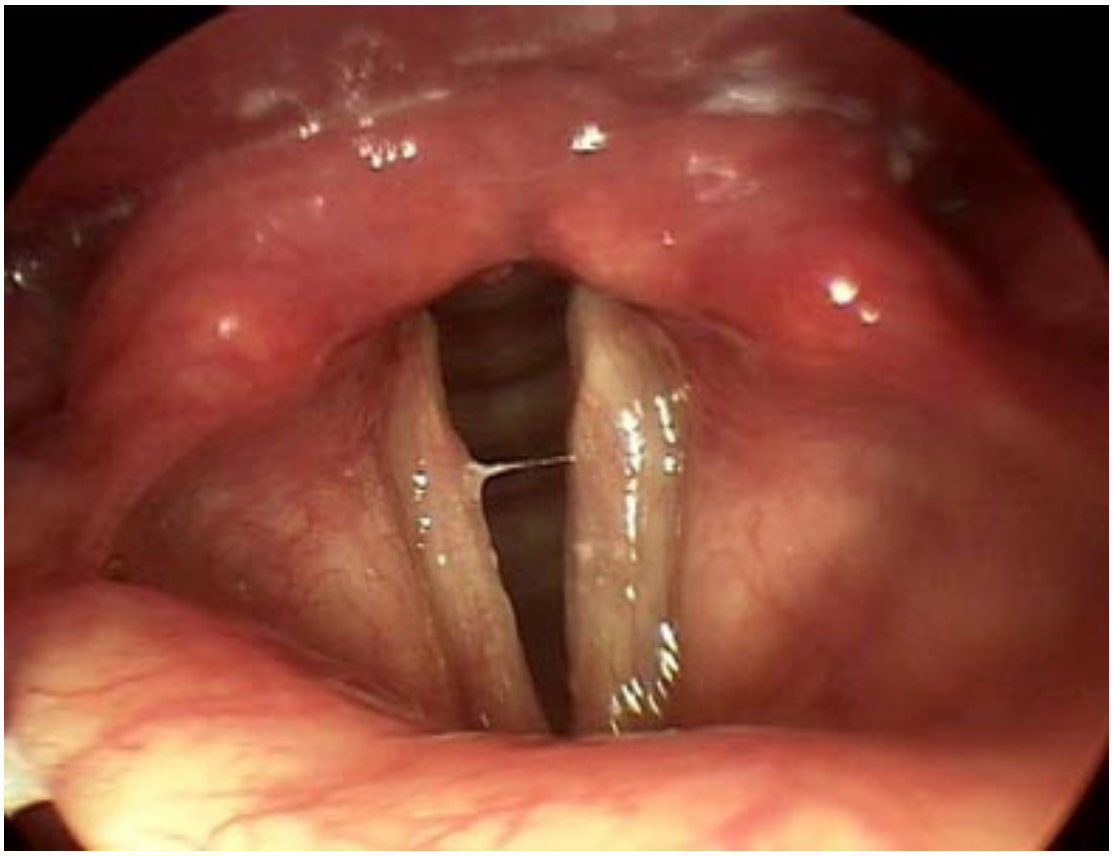
Management:

1. Cessation of smoking

2. Decreased fat intake

3. Avoiding going to bed within three hours after eating

4. Elevation of head during sleep



Endoscopic view of laryngopharyngeal reflux (String sign)

Videostrobokymography

Definition:

Videostrobokymography is a technique used to visualize the vibratory pattern of mucosal edges of vocal folds at selected coronal sections along the longitudinal glottic axis.

History:

It was originally introduced in 1970 as an analytical tool for examination of periodic / aperiodic vibration.

Uses:

1. It is used in quantitative documentation of abnormal vocal fold vibrations in various benign lesions like vocal nodules, polyps, Reinke's oedema and unilateral vocal fold palsy.

2. Analysis of glottal onset and offset

3. evaluation of the microdynamic features of the individual oscillatory cycles of the vocal folds

4. studying vocal tremor

5. imaging the mechanism of coughing

6. evaluation of the velocity of the abductory and adductory movement of the vocal folds

Procedure:

A single coronal selection / slice of vocal fold vibration recorded during stroboscopy is analyzed over specified time scale to produce a 2 dimensional image of vibrating larynx.
Normal laryngeal vibration creates a typical rhomboid kymographic pattern. Any aberration from this pattern can be considered abnormal. Videostrobokymography digitalizes
recorded stroboscopic laryngeal examination and analyzes them using a proprietary software.

Advantages of this procedure:

It does not require repeated endoscopic examination of larynx and instead allows the user to carefully analyze the video images in order to choose the optimal areas of interest.
Factors to be considered before evaluating kymographic images:

In order to accurately interpret the kymographic images one has to consider the following factors:

1. Position along glottal axis

2. Type of voice produced

Position along glottal axis:

Vibratory pattern of vocal folds is dependent on the position of vocal folds during the time of measurement. Two factors which influence the resultant image include:

Position along glottal axis

Angle with respect to glottal axis

In normal cases the middle portion of the vocal fold is considered to be representative for the vibration pattern of the whole vocal cord. In cases of vocal fold lesions
the vibratory pattern differ along the glottal axis. This point should be taken into consideration before interpreting images produced.

The angle of the measuring line is, as a standard, adjusted to be perpendicular to the glottal axis.

Type of voice produced:

There are at least three main characteristics of voice which one should take into consideration before interpreting these images:

Phonation pitch

Phonation loudness

Phonation type / voice register

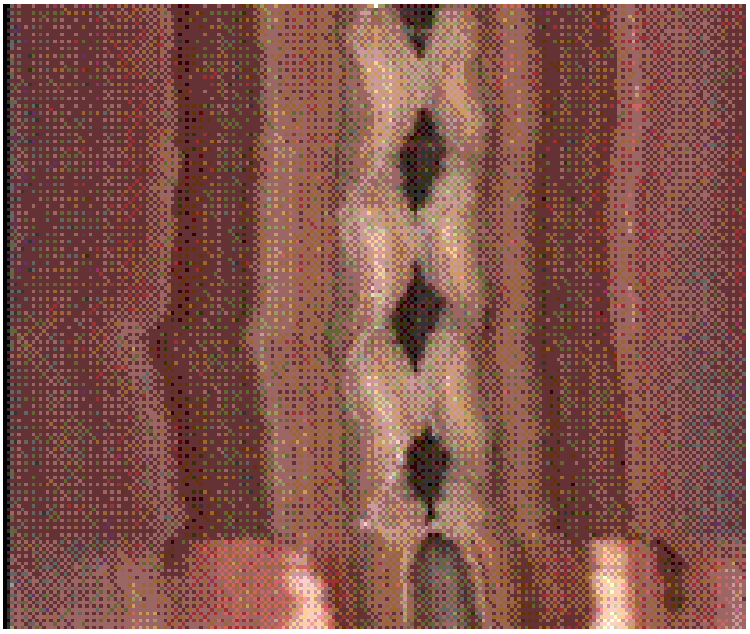


Image showing videostrobokymograph

TESPAL

(Trans nasal endoscopic sphenopalatine artery ligation)

History: This procedure was first reported by Budrovich and Saetti in 1992.

This procedure can safely be performed under GA. / L.A.

Indication:

Epistaxis not responding to conventional conservative management.

Posterior epistaxis

Procedure:

The nose should first be adequately decongested topically using 4% xylocaine mixed with 1 in 50,000 units adrenaline. A 4mm 0 degree nasal endoscope is introduced into the nasal cavity. The posterior portion of the middle turbinate is visualized. 2% xylocaine with 1 in 1lakh units adrenaline is injected in to this area to further reduce bleeding.

Incision: An incision ranging between 10 - 20 mm is made vertically about 5 mm anterior to the attachment of the middle turbinate. The mucosal flap is gently retracted posteriorly till the crista ethmoidalis is visualized. The crista ethmoidalis is a reliable land mark for the sphenopalatine artery. The artery enters the nose just posterior to the crista. The crista can infact be removed using a Kerrison's punch for better visualization of the artery.
The sphenopalatine artery is clipped using liga clip or cauterized as it enters the nasal cavity. This is done as close to the lateral nasal wall as possible, this would ensure that the posterior branches may also be reliable included.

Following successful ligation / cauterization, the area is explored posteriorly for 2 - 3 mm to ensure that no more vessels remain uncauterized.

Nasal packing is not needed.

Complications of TESPAL:

1. Palatal numbness
2. Sinusitis
3. Decreased lacrimation
4. Septal perforation
5. Inferior turbinate necrosis

This procedure in combination with transnasal anterior ethmoidal artery ligation ensures that epistaxis is controlled reliably.

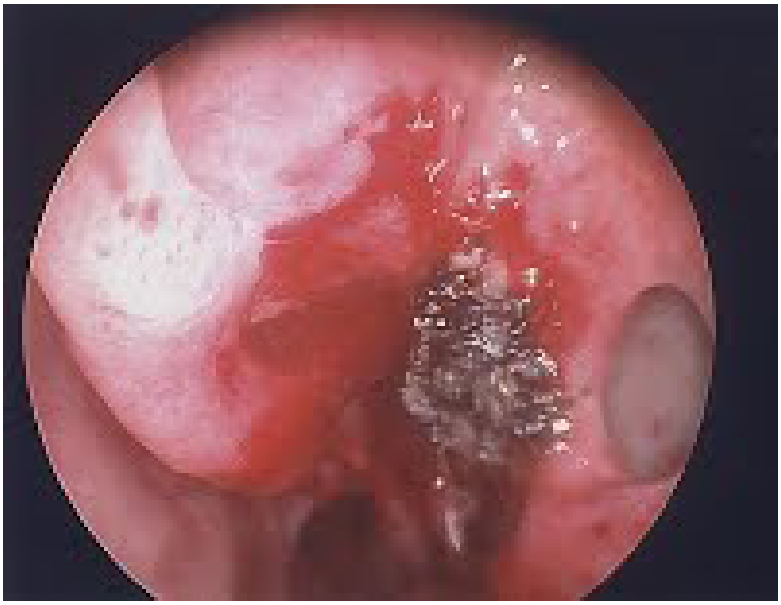


Image showing cauterized sphenopalatine artery area

Singing Voice Handicap Index

Introduction:

Singers have demanding voice needs. They are also more exposed to the risk of developing voice problems. Measuring the impact of singing voice problems from the patient's perspective will facilitate evaluation and management of patients who sing.

Classic voice handicap index: This was introduced as a tool for measuring the psychological consequences of voice disorders. This is a self administered instrument consisting of 30 statements on voice related dysfunction. It measures the emotional physical and functional problems related to voice.

Questionnaire to evaluate voice handicap index:

Never - 0 points, Almost never - 1 point, Sometimes - 2 points, Almost always - 3 points, Always - 4 points

	Never	Almost never sometimes	Almost always	Always
My voice makes it difficult for people to hear me				
I run out of air when I talk				
People find it difficult to understand me in a noisy room				
The sound of my voice varies throughout the day				
My family has difficulty in hearing me				
I use phone less often than I like				
I am tense when I talk with others due to my voice				
I tend to avoid groups of people because of my voice				
People seem irritated because of my voice				
People ask what is wrong with my voice				
People ask me to repeat myself				
My voice sounds creaky and dry				

Lower the score better is the index.

This index scores has been found to be lower in singers than non singers. This could be due to:

1. Voice problems of singers are different from that of non singers

2. Singers may be more sensitive to voice changes and may seek help fairly early

3. Voice handicap index may not be able to address singing voice problems

4. Since voice handicap index may not be sensitive enough for use in singers as important handicaps experienced by them amy go unmeasured / unnoticed.

5. Singing voice may be more susceptible to various medical disorders like reflux / allergy

With the above said factors in mind the new singing voice handicap index Questionnaire has been devised.

	Never	Almost never	Almost always	Always
Takes lot of effort to sing				
My voice cracks / Breaks				
Frustrated by my singing				
People ask "what is wrong with your voice?" on singing				
Ability to sing varies from day to day				
Voice gives out on me while singing				
My singing voice upsets me				
My singing problems make me not want to perform				
I am embarrased by my singing				
I am unable to use my high voice				
I get nervous before I sing because of my voice problems				
My speaking voice is not normal				
Throat is dry when I sing				
Have to eliminate certain songs from my performance				
I have no confidence on my singing voice				
My singing voice is never normal				
I have trouble in making my voice do what I want it to do				
Have to push it to produce my voice when singing				
Have trouble controlling breathiness in voice				
Have trouble controlling raspiness in voice				
Have trouble singing loudly				
Have difficulty staying on pitch when I sing				
Feel anxious about my singing				
My singing sounds forced				
My speaking voice is hoarse when I sing				
Voice quality is inconsistent				

My singing voice makes it difficult for audience to hear me				
My singing makes me feel handicapped				
My singing voice tires easily				
Feel pain /tickling/chocking when I sing				
Unsure whether my voice will come out when I sing				
Feel something is missing in my life because of my inability to sing				
Worried that my singing problems will cause monitory loss				
Feel left out of music scene because of voice problems				
Singing makes me feel incomplete				
Have to cancel performances				

Scores range between 0 - 144

Higher scores indicates more self perceived handicap.

This is a valid instrument for measuring patient perceived impact of singing voice problems. This can also aid in the diagnosis and assessment of dysphonic singers. This test also is a viable tool to evaluate the outcome of treatment.

Role of biofilms in the etiopathogenesis of chronic sinusitis

Introduction:

Management of chronic sinusitis is becoming difficult by the day. It is assuming importance because of its effect in the quality of one's life. Recent researches have started attaching lot of importance to the formation of biofilms in the nose and paranasal sinuses as the suspected cause for the chronicity and refractoriness of the infection.

Diagnostic criteria for chronic rhinosinusitis:

The following are the diagnostic criteria for chronic rhinosinusitis:

1. Symptoms lasting for more than 12 weeks

2. Objective findings on CT scan paranasal sinuses which include obstruction to the osteomeatal complex area, oedema of nasal mucosa, sinus mucosa.

3. Objective nasal endoscopy findings - oedematous nasal mucosa, discharge from sinus ostium, oedematous mucosa blocking the infundibular area.

What is a biofilm?

Biofilm is defined as a structured community of cells enclosed in a self produced polymeric matrix. The whole structure is adherent to a living or inert surface. The cell community could include bacteria & fungus. These cells communicate with one another in a cooperative manner.

The matrix is usually slime like, containing polysaccharides, nucleic acids and proteins.

Classic example of biofilm is the dental plaque.

A patient with chronic rhinosinusitis undergoes culture of nasal secretions to identify the causative organism and its susceptiblity to antibiotics. It should be borne in mind that in the presence of biofilm the causative organism is highly resistant to antibiotics even though culture sensitivity results suggests otherwise.

Formation of biofilm:

Formation of biofilm occurs initially as a random collection of independant free floating bacteria which attaches to the surface forming microcolonies. When the size of the colony reaches a critical point inter-bacterial cross talk starts to occur. This cross talk is known as "Quorum sensing". The process of quorum sensing initiates the process of protein expression which leads to the formation of biofilm. Generation of biofilm leads to formation of towers, layers and water channels. The exopolysaccharide matrix is formed from bacterial extrusion. Bacteria existing in the biofilm can evade the host's defence mechanisms. They are also not susceptible to antibiotics.

Biofilm also can release bacteria in planktonic forms predisposing to infection in other remote sites.

How the presence of biofilm increases bacterial resistance to antibiotics?

1. The presence of polysaccharide coat in the biofilm prevents complete penetration of antibiotics into the biofilm.

2. Antibiotics on reaching the insides of biofilm are deactivated when they interact with negatively charged polymers of the biofilm matrix.

3. Bacteria in the basal layers of biofilm are postulated to be present in an inactive state. Antibiotics dont act on non dividing microbes.

4. The pores in the cell wall of bacteria residing inside the biofilm are found to be tightly closed preventing entry of antibiotics into the cell of the organism. This closure occurs as a result of hypertonic environment present inside the biofilm.

Biofilms are supposed to be involved in:

1. Nosocomial infections

2. ICU pneumonias

3. Chronic rhinosinusitis

4. Catheter infections

5. Infections affecting a-v shunts

Stages of biofilm formation:

Stage I: Attachment of bacteria to the surface initiating a cascade of gene expression allowing the microbes to chemically communicate with each other

Stage II: Is characterised by tight adherence of bacteria to the mucosal surface

Stage III: This stage is characterised by formation of bacterial colonies

Stage IV: This stage is characterised by formation of mushroom shaped towers

Stage V: Is detachment of biofilm

Drugs if evolved which could prevent the formation of biofilm could go a long way in effectively managing chronic rhinosinusitis.

Tonsillectomy New Vistas

Introduction:

History of tonsillectomy dates back to nearly 2000 years. It was Celsius who first described the procedure in the first century A.D. The potentials for complications after this surgical procedure are still very high despite the advancements in technology. There is still no consensus between the otolaryngologists regarding the safest operating technique which is not attended by any of the classic post operative complications described after tonsillectomy.

None of the evaluated procedures has clearly shown that post operative pain could be minimized. The cause for post operative pain following tonsillectomy is due to disruption with exposure of underlying nerve endings (glossopharyngeal and vagus), and pharyngeal constrictor muscle fibres. Postoperatively exposed to external elements the exposed muscle fibres undergo spasm causing pain while swallowing. Any newer surgical technique should address this aspect of inflammation involving the pharyngeal constrictor muscles.

Subtotal intracapsular tonsillectomy:

This concept is based on minimal tissue injury. The pharyngeal constrictor muscles are not exposed. The raw nerve endings are also not exposed to the environment. The post operative pain after this procedure is very minimal and the patient undergoes a stress free convalescence period. In this procedure radio frequency probe is used. This technique is also known as "Temperature controlled radiofrequency tonsil reduction". In this technique a RF probe is introduced into the tonsillar tissue and heated up to 40 - 70° C. A plasma field containing highly ionized particles is formed at the probe's surface causing tissue destruction. This probe can thus be used to create small channels in the tonsil with dissipation of the energy released by ionizing radiations. This causes tissue destruction during the following days / weeks of surgery leading on to a gradual reduction in the size of tonsillar tissue. Initially there is an increase in the size of tonsil due to soft tissue oedema. Tonsil shrinkage usually occurs between the first and third weeks. The main advantage of this procedure is that since the tonsillar bed structures are minimally damaged, these patients are absolutely pain free even on the first post operative day.

Advantages of radiofrequency probe versus conventional diathermy / electrocautery:

1. Radiofrequency generators operate at lower frequencies than conventional electrocautery units. The cutting action of R.F. cautery occurs at 70° C. This is much lower than the cutting temperature of conventional electro cautery units which ranges between 400 – 500 ° C.
2. The high current density which is released by the electrode causes a rapid increase in the local temperature ranging from 50 – 80 ° C. This raise in temperature causes coagulation, protein denaturation and irreversible tissue destruction. When the tissue temperature reaches the critical level of 100 ° C boiling occurs at the electrode tissue interface. This boiling causes the tissue coagulum to adhere to the electrodes disrupting the current flow through the prongs.

3. Radiofrequency ablation uses frictional heating that is caused when the ions in the tissue attempts to follow the changing directions of alternating current.
4. These devises have sensors close to their tip which are capable of monitoring tissue temperatures. When the local tissue temperature reaches 100 ° C the sensor automatically shuts off the current to the generator ensuring that the tissue temperature does not exceed 100 ° C.

During RF tonsillectomy the cutting mode should be paused for 10 seconds for every 10 seconds of tissue cutting.

Cold ablation tonsillectomy: This procedure was first invented by Philip E. Eggers and Hira V. Thapliyal in 1999. This surgical procedure is performed by passing an electric current through a conductive saline media. The sodium ions in the saline are released. These sodium ions break down intracellular bonds at temperatures ranging from 45 – 60 ° C. The saline solution lowers the surrounding tissue temperature minimizing collateral excess tissue damage. Since this cold ablation technique uses bipolar probes, earthing electrodes are not necessary. Saline must be used in adequate quantities. If the amount of saline used is too low ablation fails to occur. Pressure should not be applied while using the probe tip. Application of excess pressure will cause more bleeding.

Inside out tonsillectomy: This procedure is otherwise known as intracapsular tonsillectomy. The main advantage of this procedure is reduced post operative complications like pain bleeding etc. A micro debrider can be used to perform this procedure. The rotating debrider blade is used to shave off the tonsillar tissue from its capsule. Bleeding points if any should be cauterized using bipolar cautery. The surgeon places the rotating debrider blade in the middle of the tonsillar tissue. This is done to prevent the debrider blade from straying too close to the edge of the tonsillar tissue. A retractor can be used to shield the edges of tonsil from the rotating blade. Surgeon should take care while working close to the inferior pole and anterior and posterior edges of tonsillar tissue as these areas are highly vascular. The debrider blade should rotate at full speed, otherwise suction increases and debridement ceases.

As the debrider blade penetrates the tonsillar tissue its color changes. The middle will be white and it barely bleeds. As the blade gets closer to the edge of the tonsillar capsule a red streak starts to appear. The red streak indicates the limits of tonsillar dissection.

Harmonic scalpel tonsillectomy: This procedure is performed using an ultrasonic harmonic scalpel. The sound frequency used is about 55.5 KHz. The major advantage of this procedure is reduced bleeding and post operative pain. However operating time is doubled when compared to the normal cold dissection and snare method.

Video clipping showing RF cautery being used to perform tonsillectomy

Gray's Minithyrotomy

Introduction: Vocal cord mucosal lesions always heals with scar formation causing irrepairable damage to voice. If the scarring involves the vocal ligament then it becomes nearly impossible to treat this condition. To over come this problem Gray etal in 1999 introduced the "Gray's Minithyrotomy" procedure. In this procedure through a small external incision access to the vocal fold mucosa could be obtained without resorting to mucosal incision. Usually dissection is performed along the long axis of the vocal fold recreating the Reinke's space in the bargain.

Advantages of Gray's minithyrotomy:

1. This is a minimally invasive procedure

2. Since dissection is in the submucosal plane there is no scarring of vocal fold mucosa

3. Procedure is well tolerated by patients

4. Since the line of dissection is in an antero posterior direction Reinke space is recreated if already destroyed due to fibrosis

Procedure:

This surgery can be performed under local / topical anesthesia/GA. Intravenous supplimentation can be resorted to.

Skin and subcutaneous tissue over the prelaryngeal region is infiltrated with 1% xylocaine mixed with 1:100,000 adrenaline.

Topical anesthesia: 4% xylocaine is used topically to anesthetize the laryngeal mucosa and nasal mucosa. In rare instances superior laryngeal nerve block can be resorted to.

In cases where general anesthesia was preferred, the smallest possible endotracheal tube should be used to intubate the larynx to ensure endolaryngeal visibility.

Visualization of endolarynx: This is a very important step in the whole surgical procedure. A fibreoptic laryngoscope / Rigid suspension laryngoscope is used for this purpose. A camera is attached and the vocal cord is constantly monitored in the monitor during the whole procedure.

Patient is ideally placed in supine position with the neck slightly extended using a small shoulder roll. A horizontal incision of about 1 - 2 cms is made at the lower edge of thyroid cartilage. The incision is carried through the skin and subcutaneous tissue. Fat tissue for implantation can be harvested from this area itself. Amount of fat tobe harvested is about 1 - 2 cm3.

The infrahyoid muscles are separated in the midline exposing the larynx. The thyoid perichondrium is incised in the midline, and then horizontally about 1cm along the inferior borders of the side being treated. The perichondrium is elevated superolaterally as a triangular flap. Otologic drill using a 3mm - 4mm burr bit is used to perform thyrotomy. The long axis of the drill should be aligned obliquely with the cartilage, parallel to the axis of the vocal fold. The window should be created about 3-4 mm lateral to midline and 3-4 mm superior to the inferior edge of thyroid cartilage. Pressure is applied to the drill till the inner cartilagenous cortex yields. This is the time when endolaryrngeal visualization of larynx should ideally begin.

Otologic microinstruments are suited for dissection of tissue from here on. Utmost care should be taken to avoid perforation of vocal fold mucosa. Initially, a blunt 45 degree probe is introduced through the thyrotomy window. A properly positioned probe will be seen at the undersurface of vocal fold endolaryngeally.

In cases of bowing, atrophy of vocal folds blunt dissection in Reinke's space can be performed up to the level of vocal process. In cases of scarring / sulcus vocalis the scar must be dissected sharply. Once a pocket is created fat strips created out of harvested adipose tissue should be introduced into it. Amount of fat insertion should be monitored endolaryngeally. It is always better to over correct than under correct. It should be ensured that after correction the anterior edges of vocal folds nearly meet in midline. There should be adequate posterior glottic chink for airway. Dissection over the superior surface of vocal fold should be avoided. Dissection if any should be confined to the under surface of vocal fold. If vocal fold mucosa gets perforated while dissecting, it can be sealed with perichondrium. If the perforation is large still fat can be implanted, but the extrusion rate is pretty high in these cases.

The minithyrotomy site is closed using fibrin glue / bone wax. Wound is closed in layers.

Figure showing dissection being performed in the submucosal place under the vocal folds

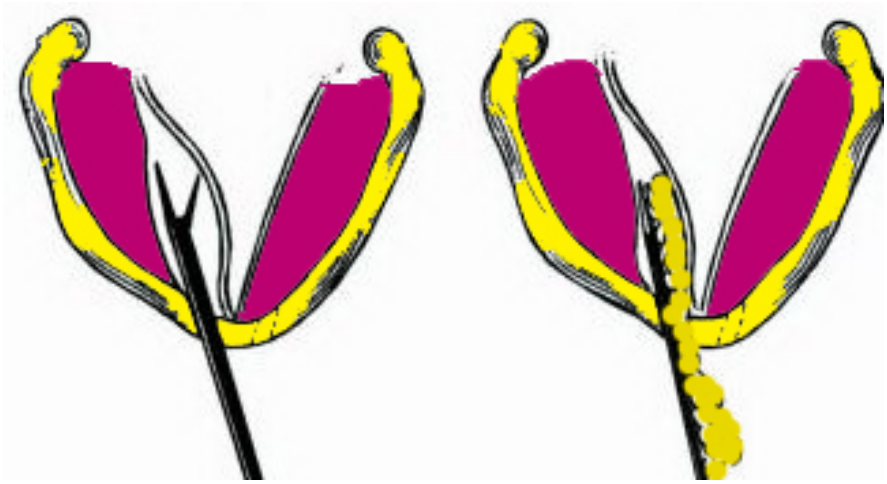
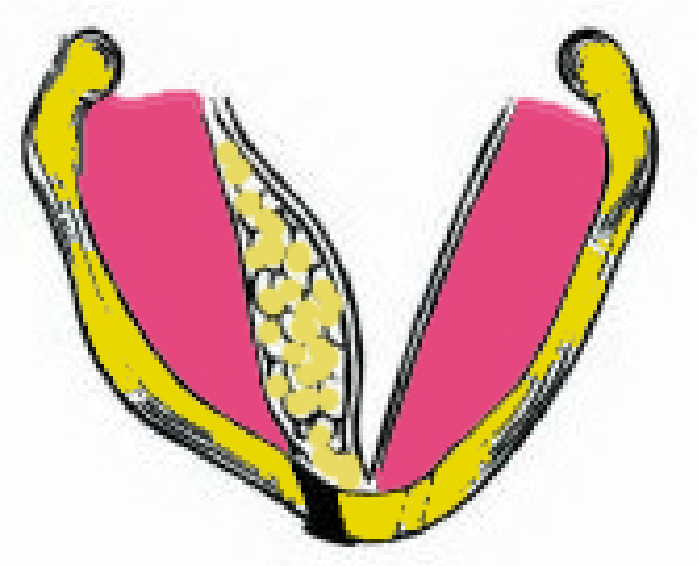


Figure showing Reinke's space being created, and fat tissue being implanted



Vocal fold after fat implantation

Indications:

1. Vocal cord palsy

2. Sulcus vocalis

3. Bowing of vocal folds

Fat implant serves dual purpose: It acts as a volume replacement, and it also acts as a barrier that prevents the elevated mucosa from scarring back down. It is also important for the pocket to be created over the medial surface of vocal folds and not over its superior surface. The inferomedial surface of the vocal fold is where the mucosal waves are generated during phonation. Fat augmentation of this surface helps in generation of good mucosal wave patterns.

Role of Leptin in Nasal Polyposis

Introduction: The term leptin is derived from the Greek work leptos which means thin. Molecularly speaking it is a 16 kilodalton protein molecule which is playing a key role in regulating energy expenditure which includes appetite and metabolism. This protein molecule is coded by the Ob(Lep) gene located in chromosome 7 in humans.

Leptin was first discovered by Friedmann in 1994. He identified that white adipose tissue is the main source of synthesis of Leptin. He also postulated that leptin could be an important biomarker for body fat. Patients who are fasting or on very low calorie diet have low levels of serum leptin.

Properties of leptin:

1. Circulating levels of leptin is proportional to body fat

2. It enters the CNS in proportion to plasma concentration

3. Receptors are found in brain neurons that regulate metabolism

4. It controls food intake and metabolism by acting on the hypothalamus

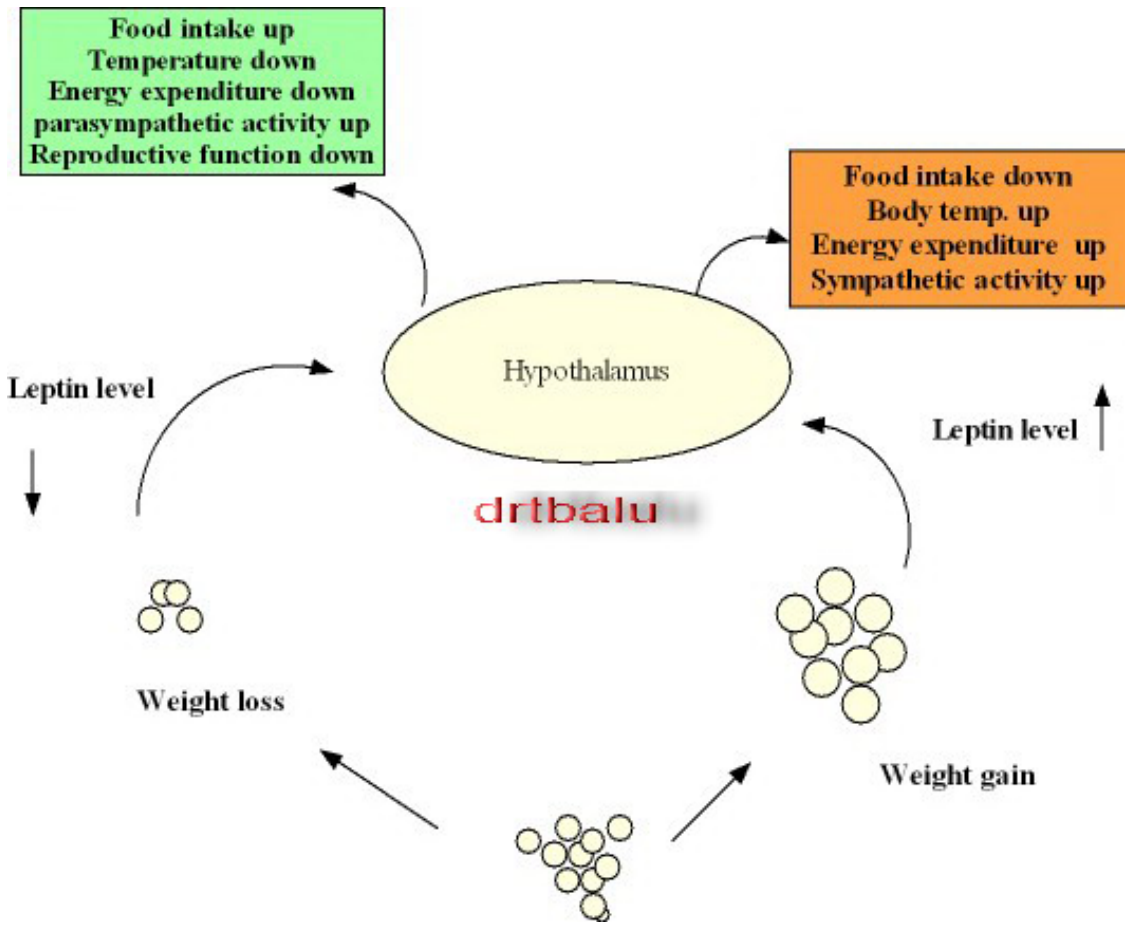
5. Leptin is a proinflammatory mediator

7. It is considered to be a member of IL - 6 family of cytokines

It has been shown that leptin stimulates release of proinflammatory cytokines like IL-6, and tumor necrosis factor alpha. Since nasal polyposis is considered to be due to chronic inflammation the role of leptin in their pathogenesis should be studied.

Nasal polyposis is considered to result from local upheaval of nasal mucous membrane. This hyperplasia could be secondary to chronic inflammation.

Studies show that serum leptin levels were significantly high in patients with nasal polyposis. It is suspected that leptin could play a significant role in the pathogenesis of nasal popyp.


Food intake up
Temperature down
Energy expenditure down
parasympathetic activity up
Reproductive function down
Food intake down
Body temp. up
Energy expenditure up
Sympathetic activity up
Hypothalamus
Leptin level
Leptin level
drtbalu
Weight loss
Weight gain

Tumor biology of head and neck malignancies

Introduction:

Most head and neck cancers result from multistep accumulation of genetic alterations resulting in clonal outgrowth of transformed cells. These genetic alterations include a variety of changes in the structure and sequence of cellular DNA within the offending clonal population. These changes result in activation of proto-oncogenes and inactivation of tumor suppressor genes. These DNA changes are caused by a variety of mechanisms like endogenous mutation and exogenous mutation. Exogenous mutations are caused by potent environmental carcinogens.

These genetic mutations cause changes in the biologic characteristics of any neoplasm like cell growth, death, motility and invasion. These mutations also influence the host's defense mechanism and immunological status. Another important aspect of tumor biology in head and neck cancers is the role played by Circadian rhythm. Circadian rhythm enables humans to adapt to daily environmental changes and also manages to synchronize various biochemical and physiologic processes with each other. These circadian clocks have known to interfere with cell cycle. An intact circadian rhythm is necessary for normal cell growth and cell death. It is hence necessary to study the role played by circadian rhythm in the tumorogenesis.

Chromosome region 9p21 loss is the most common aberration detected in patients with head and neck cancers. It has been demonstrated that 9p21 loss is one of the earliest detectable events in head and neck cancer patients. This chromosomal region loss is also commonly seen in patients with squamous hyperplastic lesions (benign) of head and neck.

Inhibition of gene p16: This gene is a critical inhibitor of cyclin CDK complexes. Inactivation of this gene permits inappropriate progression through critical G1/S cell cycle check points allowing cell division to occur unimpeded and relentlessly. This gene can be inhibited by complete deletion or by methylation of the promoter region.

Deletion of several discrete regions in chromosome 3p: This has been identified in 60% of head and neck cancer patients. The precise nature of function of this gene is still unknown.

Loss of chromosome 17p: This has been shown to occur in more than 50% of head and neck malignancies. It also correlates with p53 inactivation.

Mutation / inactivation of p53 genes: This is a tumor suppressor gene. It is of course the most extensively studied of all genes. This gene is known to suppress cell division. It induces G1 arrest till genetic repair is effected. If genetic repair is not possible it directs the cell into apoptotic pathway. It has been shown that Human papilloma virus E6 gene interacts with p53 protein causing it to degrade thus essentially inactivating it. Carcinogenesis of HPV is due to this action.

Loss of chromosome 13q: Is seen in about 60% of patients with tumors of head and neck. This portion of the chromosome is supposed to contain the RB gene. Human papilloma virus E7 another oncogenic protein is known to deactivate this RB gene. This gene has been known to negatively modulate transcription factor E2F.

Amplification of 11q13: This has commonly been implicated in 40% of head and neck cancer patients. This chromosomal area is responsible for the production of cyclin D1. Cyclin D1 is considered to be an important oncogene in the tumorogenesis of head and neck malignant tumors. Cyclin D1 is known to activate cell cycle progression.

Squamous cell carcinoma related onco-gene: This gene is activated by amplification of 3q26.3 gene. This onco-gene has been identified as one of the important initiator of squamous cell carcinoma of head and neck.

Role of growth factors in tumorogenesis of head and neck malignancies:

It is the presence of Growth factors and their receptors signals stimulus to cell division and growth in normal cells under physiologic conditions. Over expression of growth factors and their receptors can cause pathologic proliferation of cells and hence considered as products of proto-oncogenes. More than 90% of head and neck cancers over express epidermal growth factor receptor. This growth factor is encoded by c-erb

The HER-2/neu gene encodes transmembrane receptor called tyrosine kinase. Tyrosine kinase belongs to epidermal growth factor receptor group. Hence HER -2/neu gene amplification plays a role in tumor genesis.

Clinical applications: ? possible

It has been shown that nearly 50% of tumors arising from oropharynx contain oncogenic human papilloma virus DNA. As described above the tumorogenecity of HPV is due to the action of this protein on p53 chromosome. It has also been shown that patients with antibodies to HPV showed overall better survival rates. Recently the antiviral agent cidofovir when used in combination with tumor irradiation resulted in increased radio sensitivity of tumor cells.

The concept of molecular staging has been introduced. This procedure makes use of these commonly present tumor markers described above. These elements can also be used in early diagnosis of malignancies / potential malignancies. Recently therapeutic strategies have been evolved to target thee p53 mutant tumors. This is done by developing adenovirus with E1b 55 kd gene deleted. This virus is known to selectively replicate and lyse p53 deficient cells.

Cyclidin D1 has been found to be commonly over expressed in patients with head and neck cancers. Flavopiridol a CDK inhibitor has been used to repress transcription of cyclin D. This causes a cellular arrest at G2 and G1 phases of cell division. This chemical is also found to promote p53 independent cellular apoptosis. It is also known to increase the chemo / radio sensitivity of tumor cells.

Over expression of epidermal growth factor in head and neck tumors is associated with poorer prognosis. Various EGFR blockers have been devised in order to improve the prognosis. These blockers include antibodies, tyrosine kinase etc.

Acute OtitisMedia recent trends

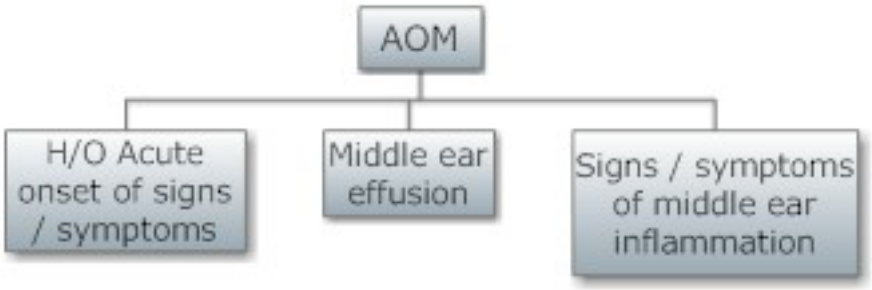
Introduction:

Definition of acute otitis media has undergone lot of changes during recent times. According to the American Academy of Paediatrics the following criteria should be fulfilled before a diagnosis of acute otitis media could be made.

1. History of acute onset of signs & symptoms

2. Presence of middle ear effusion

3. Signs & symptoms of middle ear inflammation



The presence of middle ear infection is indicated by:

Bulging of ear drum
Limited / absent mobility of ear drum
Air / fluid level behind the ear drum
Otorrhoea

Signs & symptoms of middle ear infection include:

Erythema of ear drum
Otalgia with discomfort in the ear
According to American Academy of Paediatricians clinical history had a very poor predictive value in young children.

Role of Pneumatic otoscopy:

The committee constituted by American Academy of Paediatricians has stressed the important role of pneumatic otoscopy in the diagnosis of middle ear effusion. This is one of the most important clinical examination that could identify middle ear effusion. Tympanometry can atmost supplement pneumatic otoscopy because the external auditory canal of infants is highly pliable and the resultant graph would only produce a canalogram rather than tympanogram. The extreme pliability of external canal will cause the tympanometry readings to be normal even in the presence of middle ear effusion .

Before performing pneumatic otoscopy the external canal should be cleaned off cerumen / debris. The speculum used should be of proper dimensions to cause a proper seal of external auditory canal.

Pneumatic otoscopic findings to suggest the presence of middle ear effusion include:

Fullness / bulging of ear drum causing distortion to the normal cone of light
Reduced / absent mobility
Cloudiness of ear drum - caused by oedema in the mucosal layer
Redness of the ear drum - Could be seen even in a crying child
Presence if air fluid level as seen through the ear drum
Major challenge to the attending physician is to discriminate between Acute otitis media and otitis media with effusion. This discrimination is a must because otitis media with effusion may commonly be caused by viral infections of the upper respiratory tract. It should also be borne in mind that otitis media with effusion may be a prelude to acute otitis media / may be caused by acute otitis media. In patients with otitis media of viral etiology it is prudent to avoid unnecessary use of antibiotics.

Pathophysiology:

Eustachean tube has commonly been implicated. Eustachean tube has been attributed with three functions:

Protection
Ventilation
Drainage
In patients with acute otitis media it is the protective function of the eustachean tube that takes a beating.

Management:

Pain is the most troublesome part of acute otitis media. If pain is present treatment should be resorted to. A combination of Ibuprofen / paracetomol is ideal in this scenario. It should be tried out within the first 48 hours. If pain is not alleviated then Myringotomy will have to be resorted to. Role of myringotomy is not only to let out secretions from middle ear cavity, but also to obtain specimen for bacterial cultures.

Microbiology:

Causative organisms include:

Streptococcus Pneumoniae
H. Influenza
M. Catarrhalis
Pneumococci - common in infants
Role of antibiotics:

Observation of the patient without resorting to antibiotic use is an option to be considered in the following scenario:

Children above the age of 2
Aom is devoid of complications
Diagnosis is pretty certain
Patient is ready to attend periodic follow ups

Acute otitis media in a child of less than 2 years of age is likely to cause complications. These children should be immediatly treated with a course of antibiotics. The drug of choice being ampicillin in doses of 80 - 90 mg /day in three divided doses. Lack of symptomatic improvement within 48 hours after starting the antibiotic should alert the physician the need to change the antibiotic. Drug resistance is commonly caused by Beta lactamase producing H. Influenza / M. catharrhalis. In these patients potassium clavulanate can be prescribed in addition to amoxycillin in doses of 6.4 mg / kg / day in two divided doses.

Second line antibiotics include:

Cefdinir - 14mg/kg/day in two divided doses
Cefpodoxime - 10mg /kg/day single dose
Cefuroxime - 30mg/kg/day in two divided doses
Prevention:

Encourage breast feeding of infants
Pneumococcal / Influenza vaccines
Hygiene in day care centres

Endoscopic Frontal Sinuplasty

Introduction: This procedure was first introduced at the American Academy of Otolaryngologists in

September 2005. This is infact the least invasive of all frontal sinus surgical procedures. This procedure involves introduction of a Balloon catheter into the frontal sinus outflow tract and dilatation of the balloon. When inflated this balloon widens the frontal sinus outflow tract in a least traumatic way. This dilatation does not affect the mucociliary clearance mechanism of the sinus outflow tract mucosa. Dilatation of the balloon pushes the medial wall of agger nasi cell laterally and the Bulla ethmoidalis posteriorly. The inflating balloon does not crush the agger nasi cell completely thereby reducing the incidence of post operative obstruction to frontal sinus drainage pathway.

Indications:

1. Management of isolated frontal sinus disease not responding to medical management
2. Can be used in conjunction with sinuplasty of maxillary and sphenoid sinuses
3. Can be used in combination with endoscopic ethmoidectomy as a hybrid procedure
4. It can be used to effectively identify frontal sinus ostium

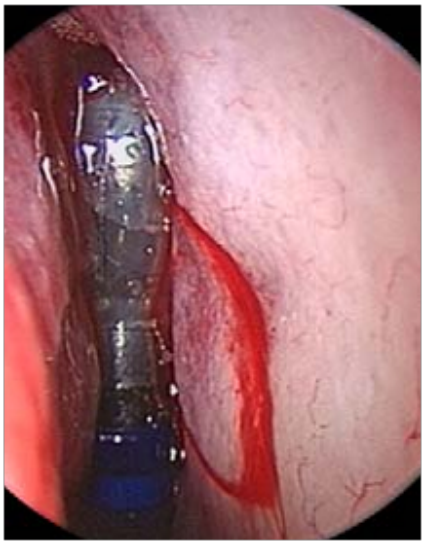
Procedure:

Instruments needed:

1. Angled endoscopes 30^0 and 70^0. These scopes will enable visualization of frontal sinus drainage tract
2. Balloon catheter and guide wire
3. Curved ball probe
4. Image intensifier

After anesthetizing and decongesting the nasal mucosa the guide wire is introduced into the frontal recess area. If there is resistance then its position can be verified using an image intensifier. If the passage is smooth the balloon catheter can be rail roaded over the guide wire. After removing the guide wire, the balloon is inflated by pushing in air after checking its position using image intensifier. On inflation the ends of the balloon fills first because the natural ostium creates a pinching effect in the middle. On increasing pressure the bone around the ostium fractures causing expansion of the bulb. This causes a dilatation of the ostium. Usually 4-6 atmospheres of pressure may be reached on inflating the balloon.

Balloon catheter in position



Baloon seen being inflated

Role of Miniosteoplastic flap in frontal sinus surgery

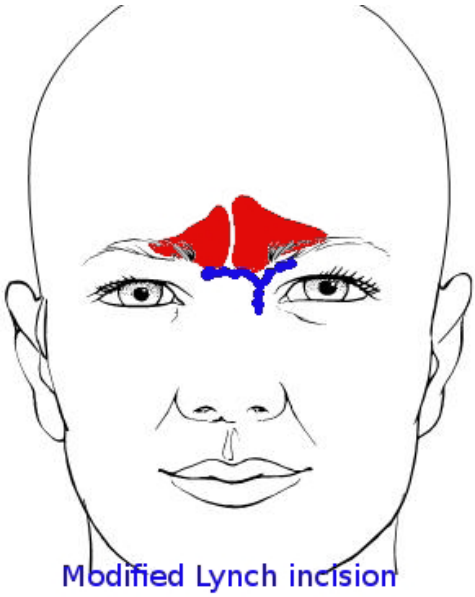
Introduction:
Access to frontal sinus is really challenging because of its geometry, varying dimensions and highly variable frontal out flow tract areas. Treatment of small frontal sinus tumors like Osteomas, encephaloceles is really troublesome because of the difficulty in accessing these lesions. Approaching these lesions using endoscopes is again troublesome due to the angulations involved. Using a bicoronal flap procedure to reach out for these small lesions is highly unwarranted. Moreover bicoronal flap procedures are fraught with complications like forehead numbness, alopecia at the incision site, paralysis of frontalis branch of facial nerve.
This is where Miniosteoplastic flap procedure can be used. The real advantage of this procedure is that it allows adequate exposure of the interior of frontal sinus through a small window created through the classical Lynch incision. With the advent of image guidance systems it is fairly simple to perform this procedure with fewer risks. This procedure was first described by Salamone & Tami. They used this procedure to remove lesions involving the posterior table of frontal sinus.

Procedure:

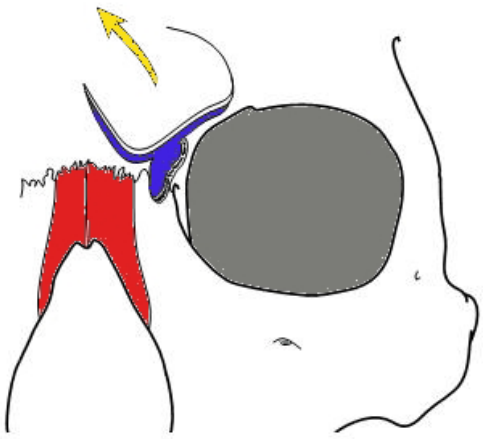
Image guidance system if available should be put to use. (Not mandatory).
Patient is positioned as for any other nasal surgery
Corneal protectors should be used to protect it
A classic Lynch incision (subciliary) is made under the brow on the side of the lesion
Another incision is made across the nasion perpendicular to this incision
Angular vein will be encountered and may cause troublesome bleeding and hence must be cauterized
Supraorbital neurovascular bundle should be preserved
Periosteum should be elevated inferiorly as this would help in retraction of orbit
Bone cut is made using a Kerrison's Ronguer in the floor of frontal sinus along the supraorbital rim up to the lacrimal bone.
A medially based Miniosteoplastic flap is created.
The bone is fractured in a superomedial direction.
The frontal sinus can now be entered.
The lesion can now be resected. The dural defect if any should be closed.
After excision of the lesion the bone flap is replaced and secured using an absorbable craniofacial plate.

Complications:

Forehead anesthesia due to damage to supraorbital neurovascular bundle.
Obstruction to frontal sinus drainage channel
CSF leaks in case dura is breached.



Modified Lynch incision



Mini osteoplastic
flap being elevated

Recent trends in the study of Inner ear development

Introduction:

Inner Ear develops from otic placode. Study of otic placode is more than a century old. Otic placode arises as a thickened patch of ectoderm adjacent to the hind brain. Ectodermal cells of otic placode starts to proliferate. This proliferation causes the placode to invaginate to form a pit (otic pit). This pit begins to deepen on further proliferation of ectodermal cells to form otic cup. The edges of proliferating ectoderm closes thus forming otic vesicle. The otic vesicle becomes a thickened ball like structure due to continuing proliferation of ectoderm. Cavitation begin to occur forming a hollow ball like structure. A lot of similarities have been identified between the development of otic placode and neural tube.

Labelling studies have shown that cells forming otic placode arise from a wide region of the embryo and converges towards the future otic placode area as the embryo matures.

Studies have shown that during gastrulation, the precursors of otic placode is mixed with cells that are destined to develop into the central nervous system, neural crest and epidermis.
What exactly prompts these ectodermal cells towards developing into otic placode? This is where inductors come into play. Embroyonic induction has been defined as an interaction between an inducing substance and a responding tissue that alters the path of differentiation of the responding tissue.

Studies have attempted to answer the following questions regarding otic capsule:
1. In what way the ectoderm forming the otic capsule is unique?
2. When exactly the process of induction starts and when it ends?
3. What are all the substances capable of induction?

Ablation and transplantation experiments have shown that ectodermal cells around the developing otic capsule are capable of forming otic capsule till the embryo reaches a specified phase in its development. These experiments have also demonstrated the importance of mesodermal elements in induction. Developing hind brain tissue also serve as inducers to a certain extent.

In the molecular level members of fibroblast growth factor family have been implicated as inducers.

Experiments have also shown that fibroblast growth factor 3 could act as a specific inducer of otic placode.

The development of inner ear takes place in three phases:

1. Phase I: Formation of otic placode. Otic placode is the earliest rudiment of inner ear, the development of which occurs as a result of interaction between surrounding tissues.

2. Phase II: This phase involves morphogenesis of otic placode to form otocyst. The otocyst is a spherical vesicle that gives rise to auditory and vestibular components of inner ear.

3. Phase III: Involves regional patterning of otocyst with the formation of antero posterior, mediolateral and dorsal ventral axis. This results in the development of three dimensional inner ear

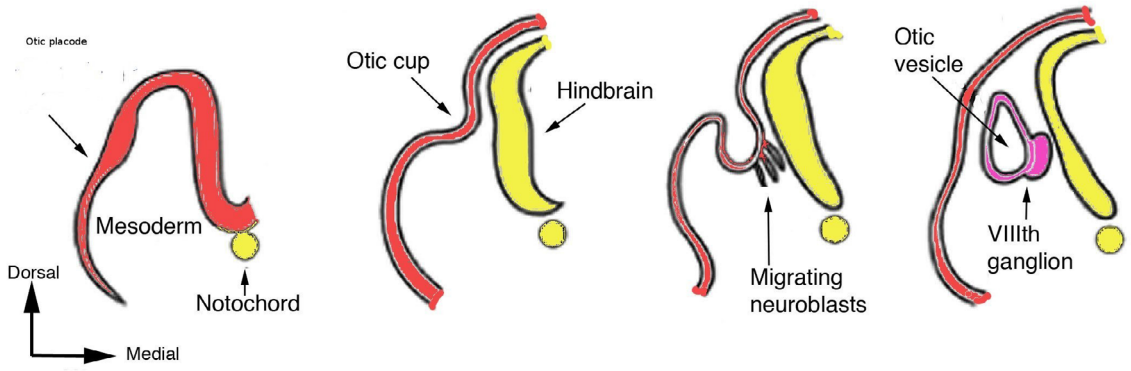


Diagram showing development of otic placode

Phase II is the most critical event in the development of inner ear. The events taking place in this phase are more or less the same in amphibians, avians and mammals. The steps involved include:

1. Changes in the shape of otic placode. The otic placode undergoes bending to form the otic pit, which is encircled by rim cells.
2. Apposition and fusion of these rim cells lead to the formation of otic vesicle / otocyst. This whole process resembles primary neurulation.

Study of the process of neurulation will help in better understanding of development of inner ear. The process of neurulation ends with the formation of neural tube which happens to be the precursor of developing brain. On humans this process of neurulation occurs in two phases (primary and secondary neurulation).

Primary neurulation: Primary neurulation results in the formation of entire brain and most of the spinal cord. It occurs in 4 stages:

1. Formation of neural plate
2. Shaping of the neural plate
3. Bending of neural plate with the formation of neural groove which is bounded on both sides by neural grooves
4. Closure of neural groove with fusion of neural folds

Secondary neurulation: This results in the formation of lower portion of spinal cord. This phase begins at the most dorsal cells of the tail bud. These cells undergoes mesenchymal to epithelial transformation leading on to the formation of the tail end of the spinal cord. This is followed by the process of cavitation resulting in the formation of hollowed out neural tube. This neural tube is identical morphologically to the primary neural tube.

Formation of neural plate in-fact mirrors the formation of otic placode. Formation of neural plate involves pallisading of cells. These cells become elongated and gets organized into a single layer of pseudostratified columnar epithelium. Cells of the placode are mitotically active and their nuclei undergoes migration as the cell cycle is reversed. The M phase of the mitotic cycle is restricted to the apical regions while the s phase is restricted to the base. It is because of nuclear migration, these cells give an appearance of being multilayerd. Spindle shaped cells are frequently seen in the neural plate. These cells as the name signifies has elongated processes both in their apical and basal ends. The nucleus is invariably located at the center. Wedge shaped cells are next commonly seen cells in the otic placode. These cells have only one elongated process in the apical region. The basal region is not elongated and is broad based. The nuclei of these cells are located closer to the basal region.

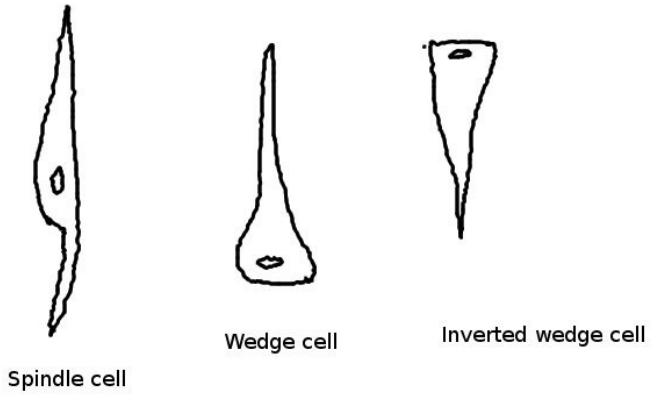


Diagram showing the various types of cells seen in otic placode

Cells in the M phase of mitosis don't possess apical / basal processes. They appear rounded. These cells of neural plate / otic placode communicate with each other along their lateral borders through gap junctions. These gap junctions are more prevalent at the apex. The cells of neural plate / otic placode possess adhesion molecules along their surfaces. These adhesion molecules are of two types:
1. Calcium dependent adhesion molecules: like N-Cadherin
2. Calcium independent adhesion molecules: like NCAM

The cells of the neural plate / otic placode (considered to be similar hence clubbed together for convenience) contains numerous apico basally elongated microtubes. These are also known as paraxial microtubules. As described previously the most important event of neural plate is the thickening which takes place. This thickening usually takes place in an apico basal direction and these paraxial microtubles play a vital role in this process. The process of thickening occurs via the process of cell elongation rather than cell stratification. Other factors which contribute to the process of thickening include:

1. Increased cell packing due to sustained mitosis
2. Increased cell to cell adhesion

The process of thickening occurs within the confines of neurectoderm. It has been clearly demonstrated that the development of otic placode resembles the development of neurectoderm in every possible way as described above. Chick embryo studies have shown:

1. Otic placode is made up of a single layer of apico basally elongated ectodermal cells
2. Interkinetic nuclear migration takes place within these cells indicating active cell replication processes
3. Apical cells (cells close to the apical zone of otic placode) undergoes active mitosis
4. Due to this proliferation the height of the otic placode increases
5. Ectodermal cells of otic placode undergoes invagination to accommodate the proliferating cells.
6. Even though otic placode increases in thickness its surface area doesn't show real time increase. This aspect is really significant.
7. Studies have also shown that the population doubling time of otic placodal cells is about 8.5 hours similar to that of adjacent non placodal cells
8. Mitotic index of otic placodal cells is 2.5 % again similar to that of adjacent non placodal cells. These aspects reveal that the development of otic placode is not the result of accelerated division of placodal cells.

According to Meier the placodal cells are restricted from growing laterally and hence resort to pseudostratification to accommodate themselves within the confines of otic placode. Electron microscopic studies of the developing otic placode showed that the cells forming the otic placode showed micro filaments in the apical zone. These cells also demonstrate large intercellular junctions close to the apical zone.

The basal lamina of the developing otic placode have been demonstrated to express the following substances:
1. Fibronectin – This glycoprotein is involved in cell adhesion, growth, migration and differentiation. It is also an important component of extracellular matrix which support the cells of the developing otic placode. Usually fibronection occurs in two forms: soluble and insoluble forms. It is the insoluble form that is responsible for the formation of extracellular matrix.
2. Cytotactin – This is an extracellular matrix glycoprotein which plays a vital role in neuronal development. It major role is to allow neuronal development and maturation in an orderly way without affecting neuronal plasticity.
3. N CAM – Also known as neural cell adhesion molecule. This glycoprotein is usually expressed on the surface of neural tissue, glial tissue, and skeletal muscle tissue. It plays a vital role in neural cell adhesion, growth of neurons, and synaptic plasticity.
4. L CAM – Also known as liver cell adhesion molecule. This is a calcium dependent cell adhesion molecule. The exact role played by this glycoprotein in otic placode development is still an enigma.

The exact roles played by these substances in the development of otic placode is yet to be elucidated.

Experiments conducted on chick embryos have proved that intact paraxial micro tubules play an important role in the normal development and differentiation of otic placode.
Shaping of otic placode: This stage resembles second stage of neurulation. Initially, the otic placode undergoes a change in shape and hence this stage is known as stage of shaping. Initially the otic placode is shaped like a shield. During this phase of development it undergoes narrowing in a medio lateral direction, and elongates antero posteriorly. This change in shape is driven by a process known as mediolateral cell to cell intercalation.

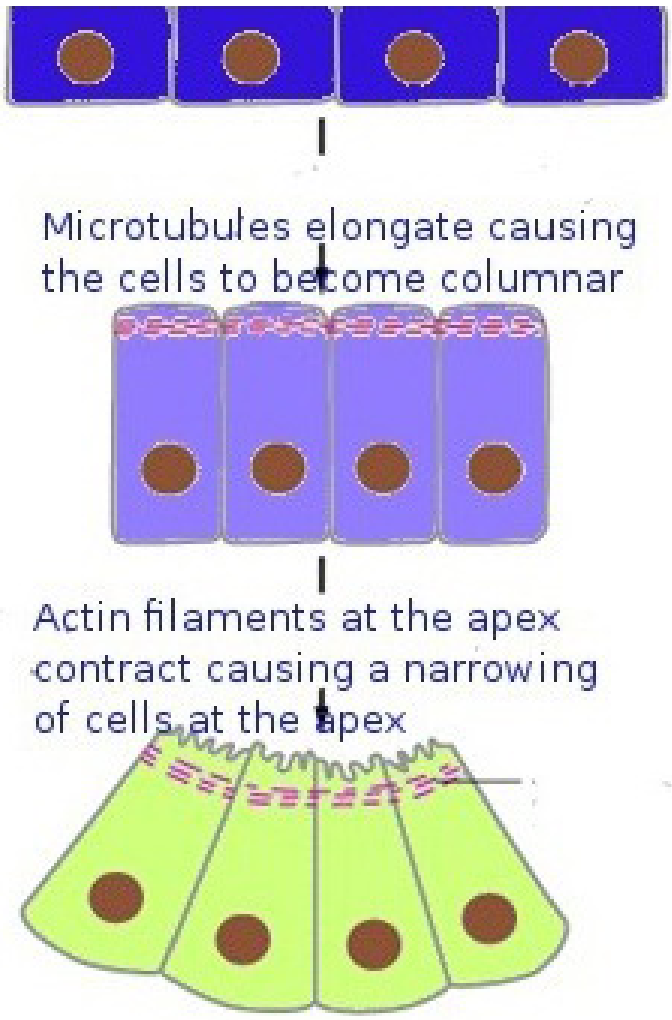

Microtubules elongate causing the cells to become columnar
Actin filaments at the apex contract causing a narrowing of cells at the apex

Diagram depicting primary neurulation

Bending of otic placode:

Bending of otic placode is caused by contraction of micofilaments present in the apex of the cell. It has been clearly demonstrated that bending of otic placode becomes possible due to intrinsic forces present in the cells of otic placode. These forces are generated by contraction of actin filaments present at the apex of the cells of otic placode. Contraction of apical microfilaments cause apical constriction and basal widening of these cells. These cells hence assume a wedge shape. This process is hence known as wedging.

Experiments performed by using the drug Cytochalasin B (this drug damages the actin filaments and prevents it from contracting) have shown that a viable actin filament contraction is a must for this stage to occur.

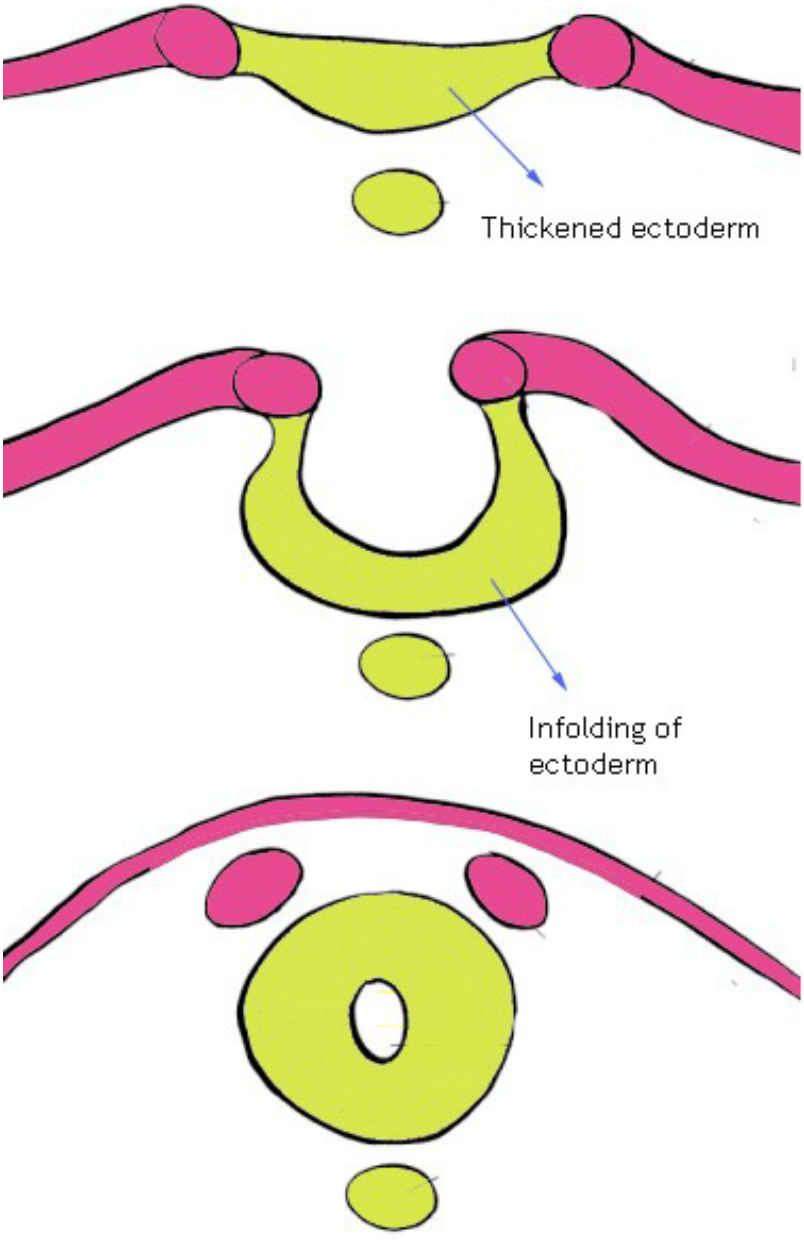


Figure showing otic placode developing into otic cyst

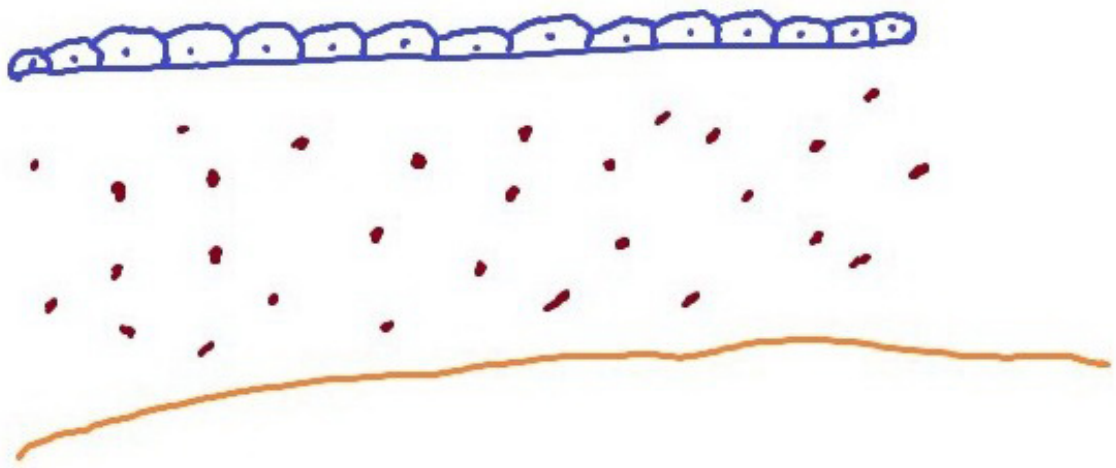


Figure showing otic placode

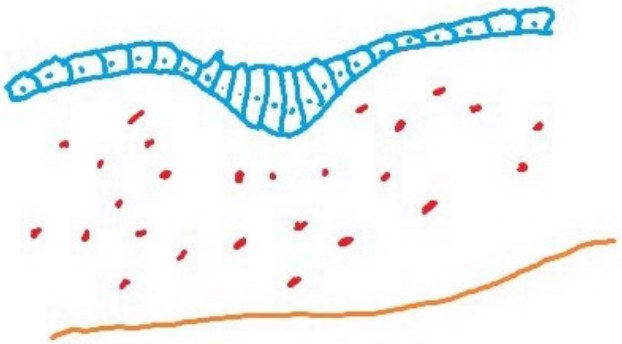


Figure showing otic placode rolling and infolding

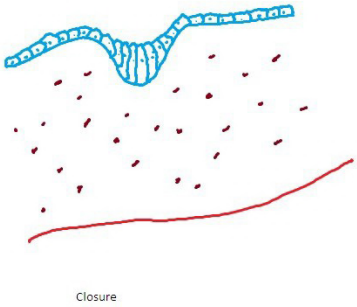


Figure showing deepening of otic placode

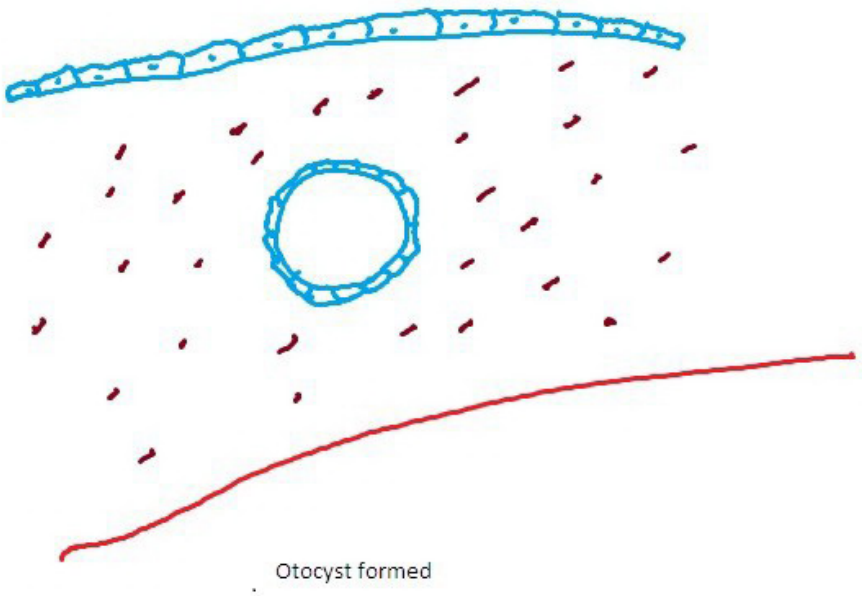


Figure showing completion of otocyst formation

During the process of bending the proportions of spindle cells, columnar cells, wedge cells and mitotic cells are maintained. Bending usually occurs around three points known as the hinge points. These points include:
one median hinge point
A paired dorsolateral hinge points
The cells around these hinge points are usually wedge shaped.
Studies have demonstrated the plausible causes of wedging. They include:
1. Contraction of apical microfilaments causing apical narrowing (Purse string effect)
2. Basal increase in size due to increased intracellular cytoplasm as these cells are in a very high mitotic state. The nucleus of these cells are present close to their base.

The process of bending in otic placode begins with the development of a longitudinal hinge point. Cells in this hinge point have basally located nuclei. Basally located nuclei indicates wedge shaped cells in the hinge zone. The otic placode epithelium is flat in nature in the non hinge areas.
The process of invagination is not dependent on calcium and ATP channels. On the other hand experiments have shown that the process of invagination is affected if the otic placode is detached from the hind brain.

Studies have also shown that the extracellular matrix surrounding the otic placode should be intact and undisturbed for the normal process of invagination to take place. Use of enzymes in experimental animals that degrade chondroitin sulfate of the surrounding matrix prevented invagination of otic placode from taking place.
Experiments using micro injections of Heparinase III into the substance of otic capsule also prevented invagination from progressing as it degrades the heparan sulfate present in the basal lamella of otic capsule.
As the process of invagination of otic capsule progresses a copious surface coating appears over the apical region of the otic capsule. The composition of this surface coat and the role played by it in further development of otic capsule is still unknown.

Role of NCAM in the process of otic invagination: NCAM is also known as Neural cell adhesion molecule. Experiments have shown that NCAM is being secreted by the epithelial lining of otic placode during the process of invagination. Experimental blockage of this molecule causes the otic placode to separate from the hind brain resulting in failure of the process of invagination.
When the process of invagination of otic placode is underway additional folds begin to appear. These folds convert otic cup into a box like structure. These additional folds include rostral and a caudal folds.

Closure of otic pit and formation of otocyst:
During the process of bending and invagination the two folds of otic placode come into contact with each other in the midline. They ultimately adhere to one another undergoing fusion, forming otocyst. Analysis of cell movements during otic cyst formation revealed that cells in the rim actively change positions. The entire dorsal rim of otocyst gives rise to the endolymphatic duct, while the postero ventral rim forms the lateral wall of otocyst. It is believed that sophisticated inter cellular signaling mechanism may play an important role in the development of endolymphatic duct and sac.

Embryologically neural tube development and otic placode development have lot of similarities. It has been demonstrated that neural tube defects caused by failure of neural tube to close happen to be the most common birth defect noticed (about 1 in 1000 live births). On the contrary defects involving otic placode and otocyst are very rare. This is rather unusual considering the fact both these structures demonstrate similarities in their development. It has been postulated that the genes responsible for development of otic cyst are also necessary for the survival of the embryo and other organogenesis. Any defect / abnormality in these vital genes will cause death of the embryo. This could only be the reason for rarity of defects involving the otic cyst.

Otic axis formation:

Ear is an asymmetric structure. It has distinct morphological features characterizing its three axis. Two axis have been identified as characteristic in a developing otocyst. These include antero posterior and dorso ventral axis. Implantation experiments have shown that the pre placodal ectoderm does not show any positional information and is dependent on the axial cues from the developing embryo. Development of otic axis is dependent on the differential responses shown by otic capsule ectoderm to the signaling molecules. The signaling molecules include Bone morphogenetic proteins (BMPs) and Sonic Hedgehog.
Experiments in chick embryos have shown that molecules belonging to Fibroblast growth factor family also play an important role in otic axis formation. Fgf3 belonging to the family of fibroblast growth factor produced by the hind brain of the developing embryo provides the Dorso ventral otic axis signal. Fgf16 another molecule belonging to the Fibroblastic growth factor group has been known to play a role in the determination of otic capsule axis.

Morphogenesis of otic vesicle:

It has been demonstrated that morphogenesis of otic vesicle begins with its elongation in a ventral direction. This process initiates cochlear development. The developing cochlea begin to coil.

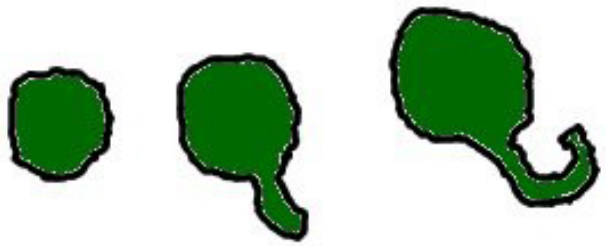


Figure showing development of cochlea

After initiation of cochlear development a dorso lateral bulge begin to develop in the otic epithelium. This bulge is known as vertical canal plate. This plate develops a groove separating the vertical plate into anterior and posterior semicircular ducts.

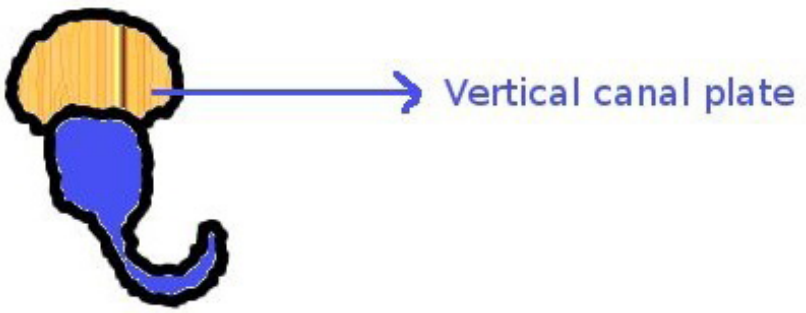


Figure showing vertical canal plate formation

Morphogenesis of epithelium of otic capsule occurs along with cellular differentiation of epithelial cells into sensory and non sensory regions. The vertical canal plate give rise to anterior and posterior semicircular canal ducts. At about the same time a bulge occurs in the lateral otic epithelium to form the lateral canal plate. The cells in the center of the lateral canal plate fuse and undergoes dissolution thus forming the lateral semicircular canal.

Each of these three developing semicircular canal ducts form a bulge at one end. This bulge forms the ampulla of the semicircular canals which house the sensory epithelium. Ventral to the completed semicircular canal system the utricle and saccule develop as bulges. These bulges eventually house the gravity sensing maculae.

The hind brain plays an important role in otic vesicle morphogenesis. Van Dyke in his classic experiments demonstrated that if the hind brain of a developing salamander embryo is replaced with the neural tissue from midbrain the developing ear becomes cystic. These studies suggest that the hindbrain produces signals that are necessary for normal morphogenesis of otocyst.

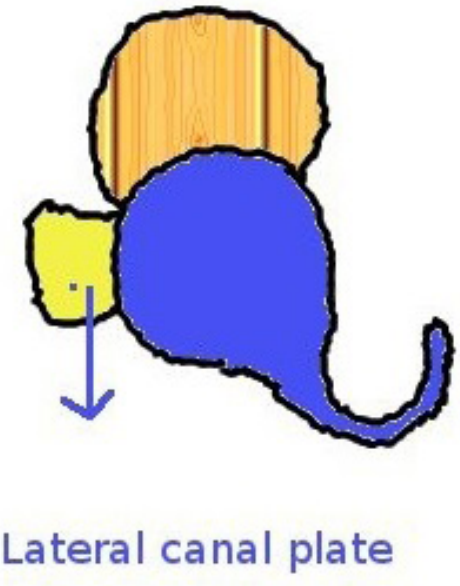


Figure showing development of lateral canal plate

Kreisler described certain mutations in his papers. These mutations go under the name Kreisler's mutations. He named the mutant gene as Kreisler gene. Kreisler mutant genes caused improper hind brain development and failure of endolymphatic ducts to develop. It has been demonstrated that the developing hindbrain sends signals to the otic vesicle which stimulates the formation of endolymphatic duct. Normally developing endolymphatic duct and sac is a must for normal morphogenesis of otic cyst.

Role of DAN protein in endolymphatic duct / sac development: Expression of DAN protein is vital for normal endolymphatic sac development. Inhibition of expression of this protein leads to the formation of an enlarged endolymphatic system. This experiment suggests that DAN protein somehow limits the function of a signal that promotes endolymphatic duct outgrowth.

Role played by Periotic mesenchyme in otic vesicle morphogenesis:
The mesenchymal lining around the developing otic vesicle undergoes chondrogenesis to form a bony capsule surrounding the membranous labyrinth. Evidences suggest that the morphogenesis of the developing otic epithelium and the periotic mesenchymal lining are mutually dependent on each other for normal development. Kann by his elegant experiments demonstrated that transplantation of otic cup to a site anterior / inferior to its normal position induced mesenchymal condensation around the newly transplanted otic tissue.

Whereas when the otic epithelium was transplanted close to the limb buds the mesenchymal condensation around otic tissue failed to develop. When the adherent mesenchyme is stripped away from the otic cyst it fails to complete its development. This proves that otic mesenchyme produced factors important for the normal development of otic cyst.

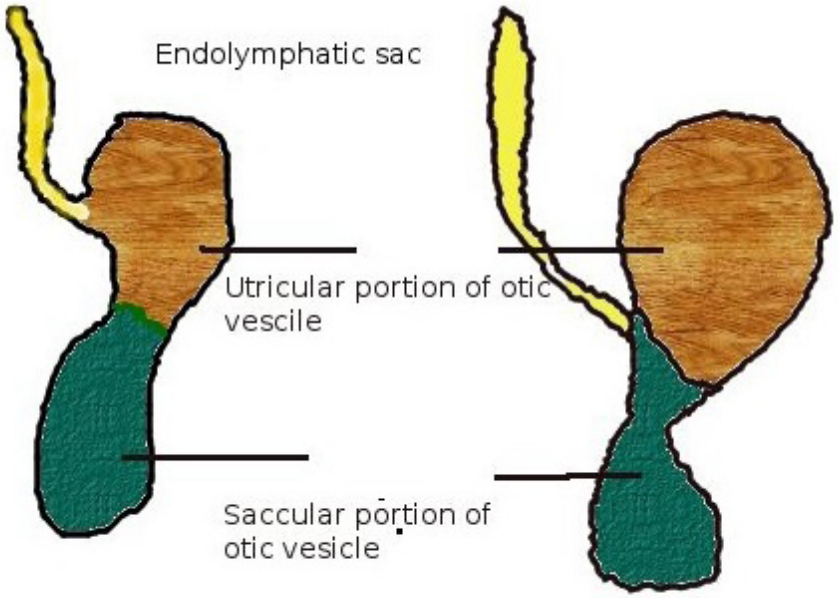


Figure showing development of endolymphatic system

Role of midline signals in otic morphogenesis:
Signals arising from notochord play an important role in determining the dorso ventral axis. The signaling molecule which is responsible for the normal dorso ventral axis of otic capsule has been identified as Shh molecule.

Role of Tbx1 mutation in otic morphogenesis:
Mutations involving Tbz1 gene are known to cause DiGeorgi's syndrome. Patients with Tbz1 mutation form endolymphatic duct after which the development of otic cup is halted. This mutation affects the mesenchymal patterning causing inner ear developmental abnormalities.
Similarly mutations involving Gata 3 genes also cause similar developmental arrest of otic cup after the formation of endolymphatic duct. The relationship between these two mutations are not clear.

Development of semicircular canals:
Semicircular canals develop as outpouchings of dorsal otic epithelium. The first outpouching occurs dorsally to form the vertical canal plate and the second outpouching laterally to form the lateral (horizontal) canal plate. Studies have identified Bone morphogenic protein (BMP) to be the signal involved in the development of semicircular canals. Studies performed using BMP inhibitors have shown semicircular canal developmental arrest.
After the outpouching the two pouches approach one another, detaching from the surrounding mesenchyme and fuse. Cells forming the interior of these pouches undergo dissolution forming the semicircular canals. Hyaluronan has been identified as the signaling agent for the fusion of semicircular canals and the dissolution of the inner cellular core leading to the formation of these canals.
After the development of semicircular canals they continue to increase in size when the ear and embryo enlarges in size. The gene which plays an important role in this stage is Nor1. The pathways this gene initiates in the later morphogenesis of semicircular canal development is still unknown.

Auditory Neurosensory development

A detailed study of auditory neurosensory development is rewarding because of the increasing incidence of sensorineural hearing loss in elderly individuals. Eventhough cochlear implants have made major strides in alleviating deafness in these patients, another emerging field "Stem cell therapy" is more promising. Studies performed in rat embryos have shown that it is possible to cause regeneration of damaged hair cells by implanting stem cells. For this procedure to be really successful the regenerated hair cells should be properly integrated with the whole of the cochlea and its nerve connections.
Development of auditory / vestibular neurosensory connections have been extensively studied.
This developmental process is possible due to the Global patterning of otocyst. This process is initiated by proper signals arising from Sonic Hedgehog genes (Shh). It is this process of patterning of inner ear that determines the potential areas of neurosensory formation. The primordial cells of primary sensory neuron present in the otocyst can easily be identified due to their ability to express certain specific markers like (Neurogenin I). These cells can also be identified as delaminating cells present around the developing otocyst. These cells become apparent during the 10th embryonic day.
Studies have shown that proper expression of certain genes are critical for the survival of certain neuronal population. Neurod I mutants demonstrate loss of cochlear neurons with intact vestibular neuronal system.
Expression of genes like Shh I, BMP and neurogenin also play an important role in proliferation of neurons. In addition to the process of global patterning another process known as local patterning of otocyst leads to the proliferation of progenitor cells that become specific sensory epithelia and their innervating neurons. These progenitor cells (also known as stem cells) have certain common features; they proliferate, self renew, and gives rise to a progeny that subsequently differentiates.

Genes determining self renewing properties of stem cells: Self renewing properties of the stem cells are determined by the presence of the following genes:
1. Sox gene family – Belongs to the High Mobility box gene group
2. Fox gene family
Various theoretical models have been described to explain the self renewing property of stem cells. The most accepted model postulates that the progenitor first undergoes multiple rounds of cell divisions causing an increase in its population. This phase is known as the "Growth phase".

Phase of asymmetric division: This is the next phase. In this phase two populations of cells are produced. One group of the product of asymmetric division is differentiated cells and the other group being undifferentiated stem cells. A progenitor stem cell that divides in an asymmetric fashion needs 4 rounds of cell division to produce 4 differentiated cells and one progenitor stem cell.
Phase of expansion proliferation: In this phase the progenitor cells undergoes cell division producing only differentiated cells. There is no net production of undifferentiated cells. About two rounds of cell division occurs allowing the cell to generate 4 differentiated cells.

Symmetric type of cell division is very fast. Cochlea undergoes symmetric type of cell division. This type of rapid proliferation of stem cells really helps the developing cochlea. It completes its development within a 5 day window. This fast mechanism allows for delayed expression of differentiating factors which occur after a sufficient number of cells are formed.
The vestibular epithelium prefers asymmetric cell proliferation as its development phase is rather prolonged. Precise knowledge of the sequence of progenitor divisions of different neural elements of otocyst is a must.
Histiogenesis: This term needs a little explanation. The whole developmental biology of human ear is dependent on this process. There is a biological clock within the stem cells that decide the rate of cell division. The precise time at which a cell exits its cell cycle is known as its birth date. There is a correlation between the fate of the cell and its birth date and this is known as histiogenesis. Classic example of this process is seen in the development of vertebral brain. Generation of neurons from the progenitor cells occur before the generation of glial cells from the same group of stem cells. Researches have revealed that in inner ear, neurosensory cells are generated over a prolonged period of time, with the development of sensory neurons predating the development of cochlear and vestibular hair cells.

The proliferative process of inner ear should be held under a tight leash as it is important for maintaining the tissue size. Genes and regulator proteins responsible for this process is still unknown as most of the regulator genes and proteins found elsewhere in the body is also found in the inner ear. It has been postulated that signals produced by proliferating neurons acts on proliferating stem cells inhibiting their division and differentiation. Neurod I has been implicated in this process. Gradual slowing of progenitor cell proliferation has been noted inner ear. Neurosensory evolution and development of inner ear is dependent on the multiplication of existing sensory patches and their innervation is mainly through proliferative expansion of the progenitor cell population.

In vertebrates neurons derive from ectoderm. These ectodermal cells get transformed into neural elements by cascading effect of a series of genes. These genes endowed with the capacity to transform ectodermal cells into neural elements are known as proneural genes. The expression of proneural genes are tightly controlled. The proneural genes are regulated by a system known as Delta – Notch system. This inhibitor system down regulates proneural gene expression in neighboring cells. This phenomenon is known as lateral inhibition. Genes responsible for activation of Delta – Notch system is bHLH genes. Upregulation of these genes cause activation of Delta – Notch system.

Types of bHLH genes:
Three functional types of bHLH genes have been identified.
1. Group I generates neural lineage of cells
2. Group II drives neural differentiation
3. Group III drives the switch that changes the lineage from neural to glial cells
Studies have shown that in mutations involving Neurog I mutant mice the ear is completely isolated from brain stem area. There are no afferents / efferents reaching the ear from the brain stem. These mutants have a fairly normal histology of the developing ear. This proves that the ear develops independent of its innervation. Hair cells are reduced in number in these patients. The cochlea is short with absent saccule. In the absence of Neurog I gene there is complete loss of neuronal progenitors, causing the hair cell progenitor to come out of the cell cycle at an earlier embryonal age than expected. This fact proves that there is significant interaction between the progenitor cells forming the primary neurons and other progenitor cells giving rise to hair cells and other supporting cells.

Growth of nerve fibers connecting the auditory / vestibular system with the central nervous system:
Bipolar sensory nerve fibers connect peripheral sense organs to the central nervous system.
These bipolar neurons show three different types of growth patterns. All these three types of growth show unique method of neuron growth.
Pattern I: In this pattern of neuronal growth, the neuronal cell migrates away from the ectoderm. It sends out an axon towards the central nervous system and a dendrite towards the sensory area. In this pattern of growth both axon and dendrite project in a direction different from the course of cell migration.
Pattern II: In this pattern the neural crest cells arising from the central nervous system migrates away from their point of origin, allowing their axons to trail behind. The migration of the cell body of the neuron determines the migration of axon. The dendritic pathway is determined by the endorgan it supplies. The target end organ should be intact and normal for the normal dendritic pathway to occur.
Pattern III: In this pattern the neural sensory cell originates from the future sensory epithelium and their cell bodies move away from the ear. Even though these cells develop from the close proximity to the sensory epithelium they need to be guided precisely to find the proper sensory patch and hair cell which they are supposed to innervate. The axons of these cells should find their path to connect to the central nervous system by following precise molecular guidance system. This system is yet to be clearly described.

The most important aspect of all the above mentioned pattern of neuronal development is the neuronal guidance system which guides the neurons to its destination.

Factors playing the part in this sophisticated guidance system include:

1. Glial axon interactions
2. Semaphorins and their receptors (neuropilins and plexins) – Roughly 16 types are present
3. Sema 3a provides the stop signal for neuronal migration (this is a type of semaphorin)
4. Cell adhesion molecules
5. Role played by hair cells – This is important in determining the survival of migrated neurons. Neurotrophins play an important role in this aspect. According to Cajal the hair cells secrete neurotrophic substances which attracts sensory afferents. There are two types of neurotrophins (Bdnf and Ntf3). Among these neurotrophins Bdnf predominates in the vestibular system while Ntf3 predominates in the cochlea.

Development of organ of corti

Alfonso Corti was the first person to describe the microscopic anatomy of the organ of corti. It was Posakony in 1999 who described that the hair cells and supporting cells of the organ of corti were arranged in a regular alternating patterns like mosaic tiles. This mosaic pattern of arrangement of hair cells and supporting cells of organ of corti is dependent on one important aspect of molecular genetics i.e. Lateral inhibition. In lateral inhibition one progenitor produces a signal that inhibits differentiation of it neighbor. This process was first conceived by Corwin et al. In cochlea the Notch signaling pathway is responsible for lateral inhibition.
Studies have shown that mutations involving the primary elements of Notch signaling pathway results in over production of neuronal elements at the expense of non neural elements. Notch signaling pathway was first identified in Drosophilia. Genes responsible for this pathway are commonly known as neurogenic genes. This pathway is activated when the notch receptor is activated by binding effects of ligand molecules. This is largely an inhibitory pathway causing lateral inhibition.

Functions of Notch signaling pathway:
1. Regulates proliferation of progenitor cells
2. It causes precursor cells to remain in a proliferative state
3. It promotes differentiation of progenitor cells
4. It plays an important role in programmed cell death (Apoptosis)
Regulation of Notch signaling pathway: This pathway can be regulated / modulated by different mechanisms. They include:
1. Functional diversity of receptors and ligands
2. Variations in ligand distribution
3. Molecules belonging to the Fringe family of proteins play an important role in modulation of Notch signaling pathway
4. Simultaneous expression of Notch and its ligands in the precursor cell

Expression of genes belonging to the Notch pathway of inner ear can be classified according to the time frame of their developmental appearance and their spatial patterns of occurrence.
1. Genes which get expressed very early in the development of inner ear (during otocyst formation or much before)
2. Genes which get expressed during the mid gestational phase of development
3. Genes which get expressed during the late gestational phase of development
In addition to the chronology of gene appearance the spatial distribution of the gene patterns should also be taken into consideration. Classification of the genes belonging to the Notch system based on their spatial distribution will go a long way in better understanding of the inner ear development.
1. Genes which are expressed very broadly
2. Genes which are restricted to certain areas / subpopulations of cells – It is these genes that are responsible for the formation of boundaries between various tissue system
3. Genes which are restricted to a small population of cells even from the very onset of expression

Genes responsible for inner ear neuronal development include:
Notch 1 (belonging to the Notch signaling system), Jag1, Dll1 and Lfng. These genes are expressed very early in the development of inner ear. Their expression is concentrated over the ventral portion of the otocyst. The expression of Notch 1 gene is associated with delamination of neurons that comprise the 8th nerve ganglion. It is also associated with the determination of sensory regions of the otocyst.
Jag 1 gene is expressed in 6 regions which include; developing saccule, utricle, three cristae and the cochlea.
Dll1 is restricted to the developing cristae.
Lfng is expressed in the developing auditory and vestibular end organs.
Notch signaling stages in the development of inner ear:
These can be described in various stages to facilitate better and easy understanding.
Stage I: This is the first and the most important stage where the notch signaling specifies the cells that will delaminate to form the neuroblasts of the vestibulo acoustic ganglion. It has been shown that during the early phases of development of ear Notch 1 and Jag 1 genes are expressed rather broadly through out the otocyst.

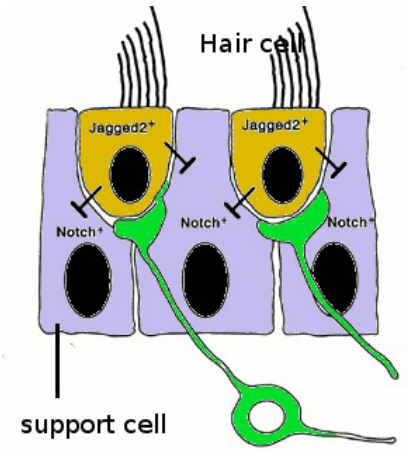


Figure showing developing hair cells and their support system

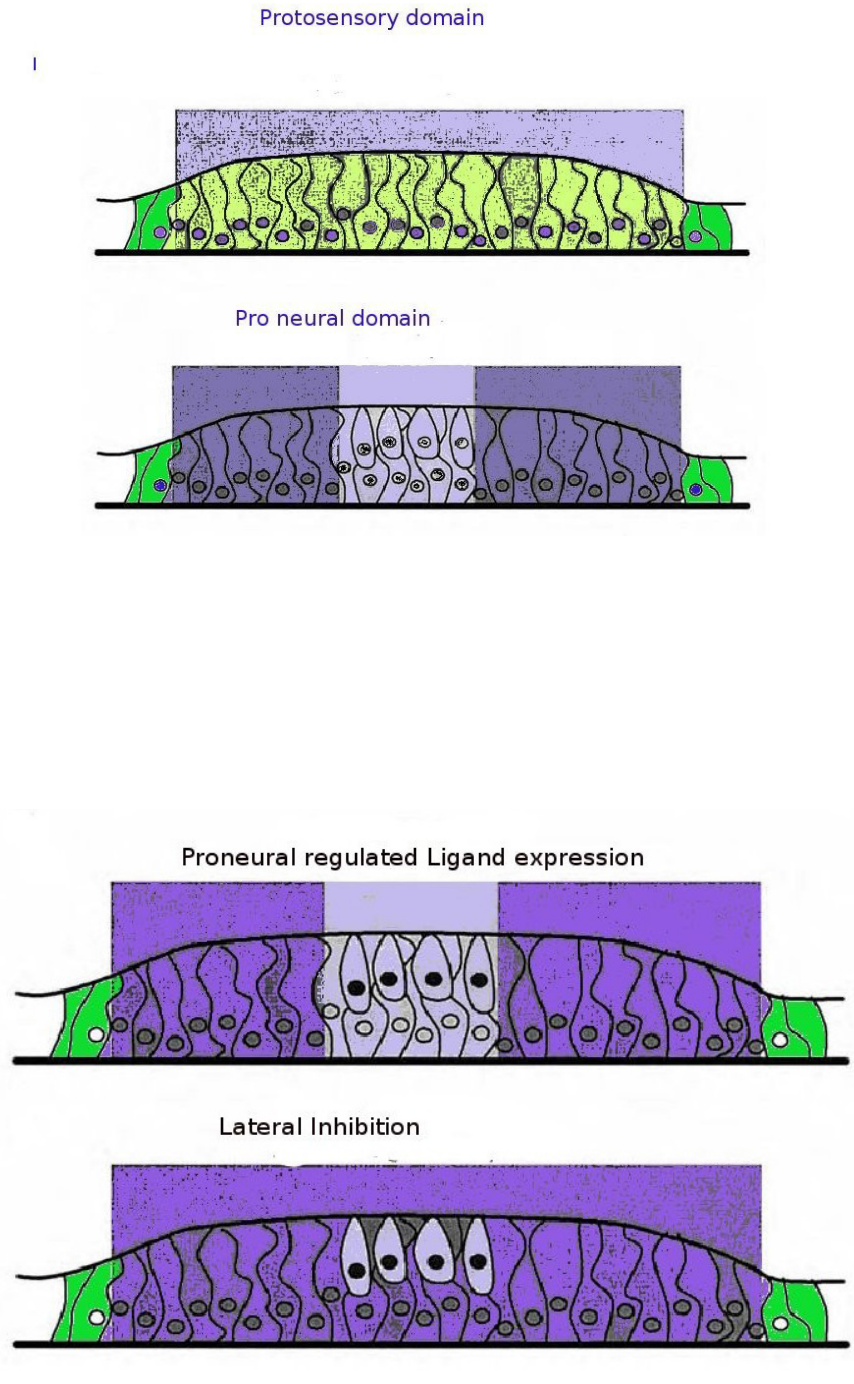


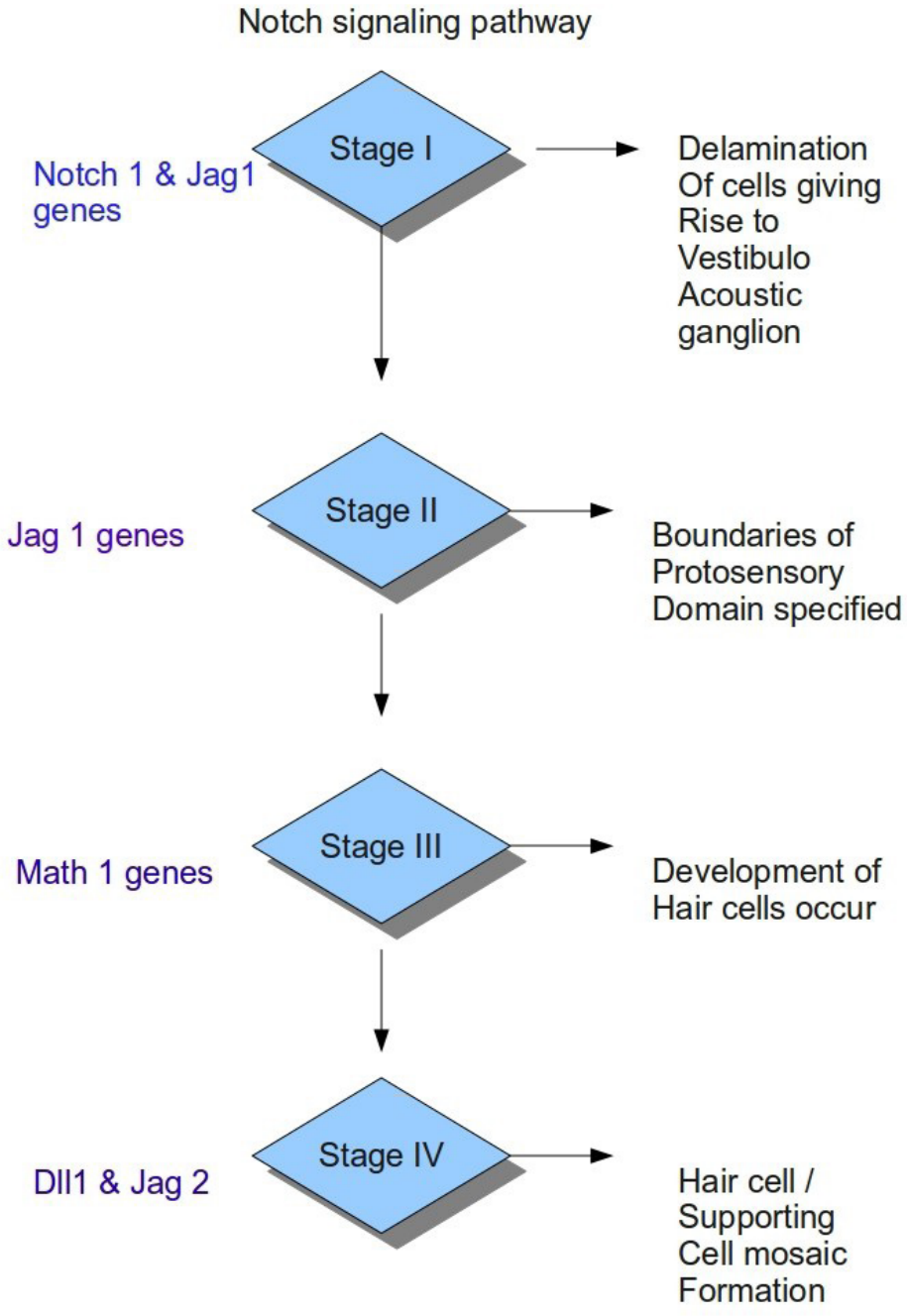
Diagram showing the Notch signaling pathway.

Jag 1 establishes a broad protosensory domain
Math 1 expression establishes proneural domain – All Math 1 positive cells develop into hair cells
Within the proneural domain specific cells begin expressing Jag 2 and Dll1 (darkened nuclei)
Lateral inhibition is caused due to activation of Notch signaling pathway

Stage II: This stage is characterized by specification of protosensory domain. This is brought about by Jag 1 – Notch signaling combination. Discrete zones of the ear develop as cells within the sensory epithelia or into cells adjacent to the sensory epithelia. This zone is collectively known as Protosensory domain / sensory patches. Expression of Jag 1 genes play a vital role in this stage. Jag 1 genes are expressed in some restricted areas of otocyst and stimulates this area into developing into cochlea, utricle, saccule and cristae.

Stage III: This stage is characterized by the development of hair cells. This action is mediated by the expression of Math 1 genes. Usually Math 1 positive protosensory domain cells develop into hair cells. Cells of the protosensory domain that don't express Math 1 gene develops into supporting non sensory cells.

Step IV: This is the end stage of Notch signaling system. The major feature of this stage is lateral inhibition. The end result of this stage is the mosaic formation between the hair cells and supporting cells. Genes which are active during this stage include Dll 1 and Jag 2 gene expression.


Notch signaling pathway
Stage I
Notch 1 & Jag1 genes
Delamination Of cells giving Rise to Vestibulo Acoustic ganglion
Stage II
Jag 1 genes
Boundaries of Protosensory Domain specified
Stage III
Math 1 genes
Development of Hair cells occur
Stage IV
Dll1 & Jag 2
Hair cell / Supporting Cell mosaic Formation

Hair cell differentiation:

The factors necessary for initiation and completion of hair cell differentiation reside within the sensory epithelium itself. Hair cell innervation play no role in their development. Hair cells do develop even in the absence of development of connecting neurons. The presumptive sensory epithelium from which the hair cells develop are columnar in nature. These unspecialized columnar cells are inter connected with the help of gap junctions. Once these cells develop into hair cells these features are lost. Experiments have shown that the down regulation of connexin genes is one of the earliest events in hair cell differentiation. Loss of gap junction play an important role in cellular differentiation. This loss of gap junction prevents integrins from getting into contact with the developing cell. In the absence of integrin exposure the cells develop into hair cells.

Once a progenitor cell becomes differentiated into developing hair cells, they start secreting the following molecules:
1. Calcium binding proteins like Calmodulin and Calretinin
2. Micro tubule protein Tuj 1
3. Certain myosins
Hair cell bundles first make their appearance in the vestibular portion of the developing inner ear. This is due to the fact that vestibular component of the inner ear is phylogenetically older when compared with that of the cochlear component. As far as the hair bundles of the cochlea is concerned, they are first seen close to the apex of the developing cochlea (low frequency end).
A lot of research is being performed in the field of embryology of inner ear.

Role of Intraoperative Imaging in Endoscopic Skull Base Surgery

Introduction:
Advances in nasal endoscopic surgery have prompted the surgeon to explore hither to unexplored vistas, like skull base surgery. It has been proved that endoscopic skull base surgery has helped in the reduction of morbidity and mortality of classical craniofacial approaches. Technologically superior endoscopes with wide field of vision, better illumination, camera and monitors have improved the success rate of these surgical procedures. These rigid endoscopes despite their obvious advantages provides only a 2 dimensional view of a complex 3 dimensional space. Image guided surgery was popularized in order to provide a certain degree of 3 dimensional view. Image guided surgery is heavily dependent on preoperative image data collection, resulting in a scenario of non visualization of the anatomic manipulation caused by the surgical procedure. This is where intraop imaging score over conventional image guided surgery because of its real time imaging ability. The operating surgeon will be virtually seeing the imaging of his surgical procedure.

Advantages of intraop imaging:

1.Provides real time images of the surgical field
2.These images can be fed into the image guidance system for better visualization of the surgical field. In other words it gives real time updates for image guided surgery.
3.Intra op imaging may help in performing extensive skull base surgeries using an endoscope.
4.It may be useful in managing complex craniofacial fractures

Equipment specification for intrao op imaging:

1.Equipment for image acquisition
2.Equipment for transferring the acquired image
3.Equipement for viewing and manipulation of acquired images
4.Software necessary to upload these real time images to the navigation system
5.A computer workstation to make all these things possible

Intra op imaging equipment should ideally be:

1.Portable
2.Capable of rapid image acquisition
3.Compatible with already commercially available image guidance systems
4.CT scanner / MRI scanner can be used for intra op imaging. CT scanner is preferrable because of its rapid scanning time, and excellent bone details which it provides.

Role of Cone Beam CT in intra op imaging:

This is slowly replacing conventional in office x-ray machines. It is very useful for rapid diagnosis of sino nasal and otological disorders. This CT machine permits imaging of the structure in question within single rotation. It uses the technique of volumetric tomography. Other major advantages of this imaging modality is reduced time of scanning and reduced exposure of the patient to harmful effects of irradiation. It is also comparatively less expensive than MRI scanners. These devices are highly portable and can be effortlessly wheeled into the operating room.

Image showing a Portable CT scanner

Three dimensional fluroscopy:

This is the other popular method of intra op imaging. It is highly portable and maneuverable. Patient is placed between the fluroscope and image intensifier. The image acquired is viewed on a portable workstation monitor. Softwares are available for converting the 2 dimensional image data acquired to 3 dimensional ones.

It should always be borne in mind that intra op imaging at the most provides complimentary information to the endoscopic portion of the surgical procedure.

Limitations of intra op imaging:
Are nothing but limitations of Cone Beam CT scanning. Due to technological limitations there is some loss in the quality of soft tissue imaging. Infact fluid / blood within the sinus cavity may be confused with that of residual mass / polyp. Hence intra op imaging should always be interpreted in conjuction with the endoscopic vision.

Sonotubometry and its role in assessing the functional integrity of eustachean tube

Introduction:
Sonotubometry is based on the principle that sound when applied to the nasopharyngeal ostium of eustachean tube will be conducted through the eustachean tube into the middle ear when it opens. This concept was first conceived durning the 19th century. It has undergone lot of changes like introduction of better microphones. Politzer should be credited for the introduction of sonotubometry for analysis of eustachean tube function.

Principle:
In principle sonotubometry records changes in sound pressure level in the external auditory meatus when a constant sound source is applied to the nostril. In theory the eustachean tube opening will cause an increase in the sound pressure level of middle ear cavity causing a retrograde conduction of sound from the middle ear to the external canal which is recorded by a sensitive recording device. For this to occur the eustachean tube should open and close normally. By just recording the sound which is transmitted from the nose to the external canal via the eustachean tube it is possible to assess the functional integrity of the eustachean tube.

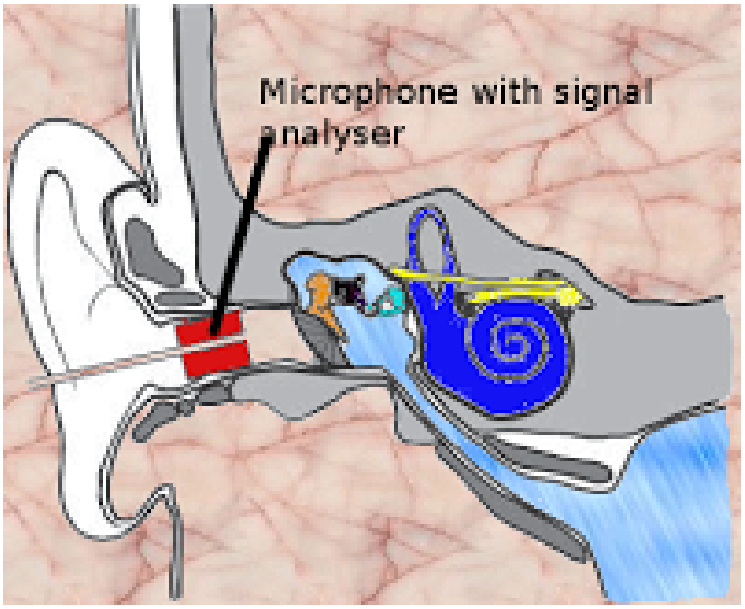


Diagram showing the placement of microphone in the external canal to record the transmitted sounds.

Advantages of sonotubometry:

The whole procedure is performed under physiological conditions

Static pressure is not applied over the external auditory canal

The whole procedure is independent of the status of ear drum

Pitfalls of sonotubometry device:

Leakage of sound from the nostrils and external auditory meatus

Identifying the optimal frequency of test sound that should be used

Results got corrupted due to the physiological noise of swallowing

These pitfalls were overcome by using inflatable nasal seals that would prevent leakage of sound from the nose and the use of pneumatic valve on the meatal microphone. This pneumatic valve would ensure that the external canal is sealed properly and there is no leakage of sound from it.

Regarding the frequency of test sound that should be used it has been demonstrated that frequencies between 6-8 kHz usually produced the best results. It has also been determined that frequencies of 5 kHz usually could be mistaken to that of physiological noises produced due to the act of swallowing.

Procedure:
The test is usually performed by placing a pneumatic microphone inside the external canal and a nasal sound probe which could generate sound at frequencies ranging from 6-8 kHz. Patient is asked to take about 20ml of liquid and hold it inside the oral cavity. When the sound is projected via nasal probe the patient is asked to swallow the liquid. This act of swallowing will open the normally functioning eustachean tube and is considered to be normal if the sound recorded at the external auditory canal reaches the level of 4dB sound pressure level. The duration of the eustachean tube opening can be calculated as the time difference between the onset of increase in the amplitude of sound and the return to its baseline.

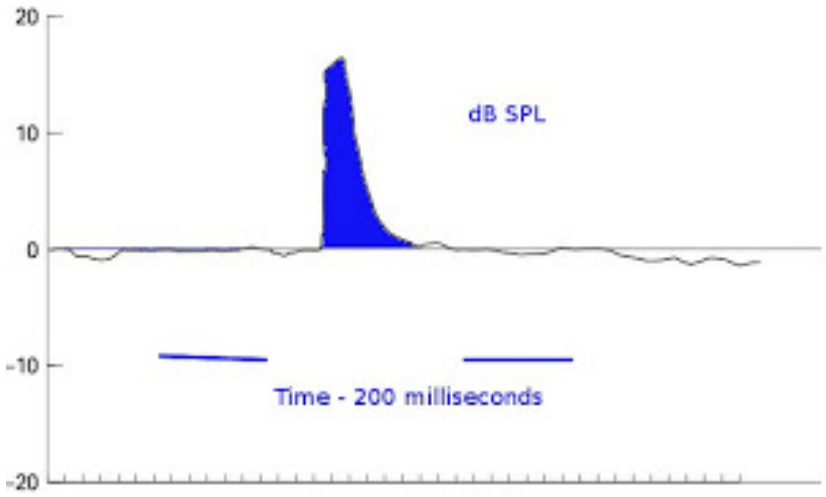


Figure showing the sonotubometric curve. SPL reaches the peak level at the external canal 16 dB at 500 milliseconds. The base of the triangle formed by the curve is the time which eustachean tube is kept open. By looking at this curve eustachean tube functional abnormalities can be identified.

Infantile Hemangioma Role of Propranolol in its management

Introduction
Hemangiomas are common in children. It is seen in 1 in 10 of all children. About 50% of all hemangiomas in children are located in the head and neck area. Majority of them are single lesions which are inconspicuous at birth but undergoes rapid growth throughout the first year of life. Studies have also demonstrated that infantile hemanigomas are more common in premature infants. This has been attributed to the fact that mothers with premature uterine contractions receive tocolytics which are potential vasodilators.

Theories of infantile hemangioma:

1.Infantile hemangiomas have been postulated to originate from placenta – Studies have shown that endothelial cells constituting infantile hemangiomas resemble placental vessels
2.Mutation of endothelial cells
3.Environmental factors have been postulated to stimulate growth of these infantile hemangiomas

Regulators of hemangioma growth:

The topic of regulators involved in the growth and involution of infantile hemangiomas is still in infancy. Histologically infantile hemangiomas is composed of a mixture of clonal endothelial cells, pericytes, dendritic cells and mast cells.

Hemangiomas usually appears within the first few weeks of birth, undergoes rapid increase in size as the infant grows. The increase in size of infantile hemangiomas is much more rapid than that of infant's growth curve. This active proliferative phase is characterized histologically by plump endothelial cells showing evidence of frequent mitosis, increased number of mast cells and multilaminated basement membranes. Studies have demonstrated the involvement of two angiogenetic factors during this phase, they are basic fibroblast growth factor (bFGF) and vascular endothelial growth factor (VEGF). This phase of active proliferation is followed by a phase of spontaenous slow involution (possibly due to apoptosis). This phase is characterized histologically by the presence of flat inactive normal looking endothelial cells in a matrix of fibrofatty tissue.

Treatment modalities:

1.Oral steroids
2.Systemic steroids
3.Cyclophosphamide
Among the above three treatment modalities systemic steroids offer the best results, of course with its attendant complications. Intralesional steroid injections have caused significant reduction in the size of these masses.

Use of Propranolol in the management of infantile hemagiomas was noticed by accident when a few children who underwent treatment for their cardiopulmonary conditions with propranolol showed significant reduction in the size of the hemagiomatous lesions. This led to a flurry of activity in the medical world. Propranolol was discovered by Sir James Black. It is a non selective beta blocker which revolutionized cardiac and hypertension management for a long time.

Therapeutic effects of propranolol in hemangioma:

1.Vasoconstriction – The ability of this drug to cause constriction of blood vessels supplying hemangioma tissue will cause significant reduction in its size. The hemangioma also undergoes significant softening in response to propranolol
2.Down regulation of angiogenetic factors like bFGF and VEGF
3.Upregulation of apoptosis of capillary endothelial cells

Dosage:

Propranolol should be administered during the proliferative phase of infantile hemangiomas in doses of 2-3 mg /kg /day divided into 2-4 doses.

Precaution:

The drug should not be discontinued abruptly and should be done in a tapered manner (during the period of 2-3 weeks) to prevent rapid increase in the size of the lesion.

Blow out fracture current management trends

Introduction:
Blow out fracture of orbit is defined as fracture of one or more of its internal walls. This injury is typically caused by blunt trauma to orbit. In pure terms this definition does not involve the orbital rim. If fracture of orbital rim is associated with fractures of one or more of its internal walls then the term complex blow out fracture is used. Even though there is nothing complex about it, this term is used to stress the importance of non involvement of orbital rim in blow out fracture. Blow out fracture is actually a protective mechanism which ensures that sudden build up of intraocular pressure which could be detrimental to vision does not occur following frontal injury to orbit.

History: Blow out fracture of orbit was first described by Lang in early 1900's. The exact description of the fracture and the terminology (blow out fracture) was first coined by Converse and Smith. It was infact Smith who first described inferior rectus entrapment in between the fractured fragments, causing decreased ocular mobility.

Anatomy of orbit:
A brief discussion of anatomy of orbit will not be out of place here. Bony orbital cavity is formed by contributions from:
1. Lacrimal bone
2. Orbital process of maxilla
3. Orbital process of zygoma
4. Orbital process of frontal bone
5. Ethmoid bones

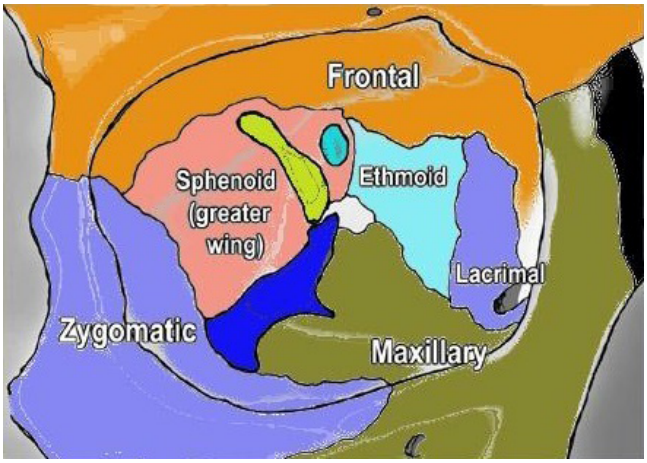
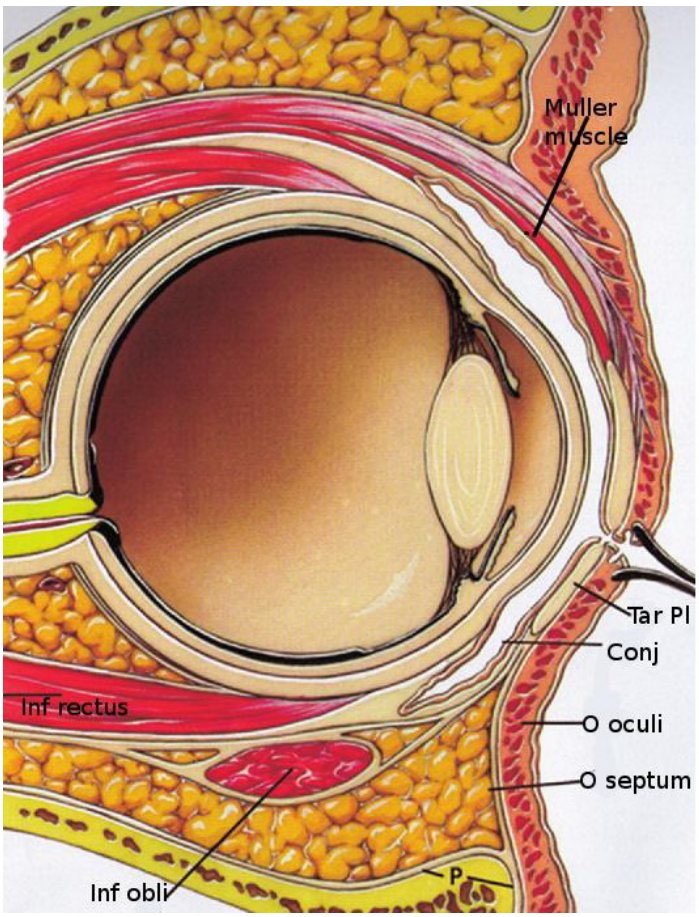


Diagram showing anatomy of orbit

The medial canthal tendon attaches via a thick limb to the anterior lacrimal crest and by a thinner limb to the posterior lacrimal crest. This thinner limb contains the Horner's muscle. Similarly the lateral canthal ligament also contains two limbs. The thin anterior limb blends with the orbicularis oculi muscle and the periosteum of lateral orbital rim. The thicker posterior limb gets attached to the Whitnall's tubercle of the zygoma. The medial canthal tendon is intimately related to the lacrimal system.
The upper and the lower puncta begin 5 – 7 mm lateral to the medial canthus and continue as common cannaliculus into the lacrimal sac located between the anterior and posterior limbs of medial canthal tendon within the lacrimal fossa. The lacrimal sac empties its contents into the inferior meatus through the nasolacrimal duct. The lacrimal gland is located in the lateral portion of the upper lid. It is divided into a larger orbital and smaller palpebral portion by the lateral horn of levator aponeurosis. Anteriorly the gland's orbital portion is in contact with the orbital septum.

Extraocular muscles: Include 2 oblique and 4 rectus muscles. The superior oblique muscle due to its oblique course is in direct contact with the periorbita of the roof, and medial wall of orbit at the level of trochlea. All the 4 recti muscles arise from the annulus of zinn and gets inserted into the sclera.



Anatomy of orbit lateral view

Classification of blow out fracture:

1. Orbital floor blow out fracture - Commonest
2. Medial wall blow out fracture – This is rare even though it is lined by the paper thin lamina papyracea, because of the support it receives from the bony Ethmoidal labyrinth.
3. Superior wall blow out fracture – rare
4. Lateral wall fracture – involves zygoma

Signs of blow out fracture:

1. Periorbital ecchymosis (very commonly seen in blow out fractures)
2. Disturbances of ocular motility
3. Enophthalmos
4. Infraorbital nerve hypoaesthesia / anesthesia

Puttermann in 1974 firmly believed that no patient with blow out fracture of orbit should undergo surgical reduction before 4 -6 weeks after injury. He firmly believed that given time tissue oedema and hematoma will regress improving patient's condition.

Theories accounting for blow out fracture: The exact mechanism causing blow out fracture is yet to be elucidated. Two theories have been going around for quite sometime. They are:
1. Buckling theory
2. Hydraulic theory

Buckling theory: This theory proposed that if a force strikes at any part of the orbital rim, these forces gets transferred to the paper thin weak walls of the orbit (i.e. floor and medial wall) via rippling effect causing them to distort and eventually to fracture. This mechanism was first described by Lefort.

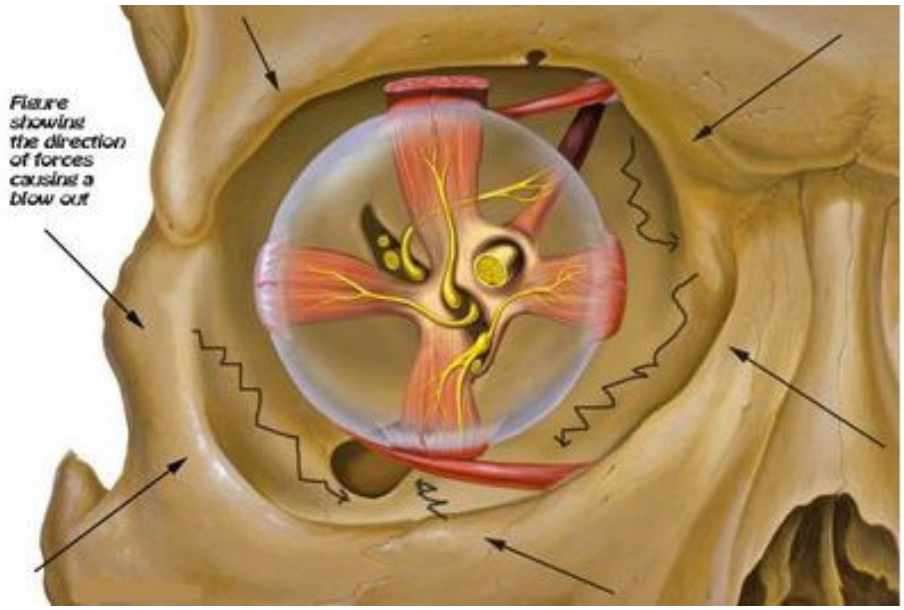


Figure showing the direction of forces via the rippling effect accounting for the Buckling theory

Hydraulic theory: This theory was proposed by Pfeiffer in 1943. This theory believes that for blow out fracture to occur the blow should be received by the eye ball and the force should be transmitted to the walls of the orbit via hydraulic effect. So according to this theory for blow out fracture to occur the eye ball should sustain direct blow pushing it into the orbit.

Water House in 1999 did a detailed study of these two mechanisms by applying force to the cadaveric orbit. He infact used fresh unfixed cadavers for the investigation. He described two types of fractures:
Type I: A small fracture confined to the floor of the orbit (actually mid medial floor) with herniation of orbital contents in to the maxillary sinus. This fracture was produced when force was applied directly to the globe (Hydraulic theory).

Type II: A large fracture involving the floor and medial wall with herniation of orbital contents. This type of fracture was caused by force applied to the orbital rim (Buckling theory).

Clinical features of blow out fracture:

. Intraocular pain
. Numbness of certain regions of face
. Diplopia
. Inability to move the eye
. Blindness
. Epistaxis

Patient may also show signs of:
. Enophthalmos – This can be measured objectively by Hess charts and Binocular single vision.

. Oedema
. Haematoma
. Globe displacement
. Restricted ocular mobility
. Infraorbital anesthesia

Proptosis in these patients is sinister because it indicates retrobulbar / peribubar hemorrhage.

Pupillary dysfunction associated with visual disturbances indicates injury to optic nerve and it is an emergency. Patient must be taken up for immediate optic nerve decompression to save vision.

A complete ophthalmic examination is a must in all these patients.

Indications for surgical repair:

1. Persistent diplopia in the primary position of gaze
2. Symptomatic disturbance of ocular mobility – if persisting for more than 2 weeks is considered to be an absolute indication by many. This two week window is considered because it is the time taken by edema / hematoma of orbit to resolve. Two weeks after the injury fibrosis and adhesions begin to develop. Any surgery performed before development of adhesions / fibrosis has best results.
3. Radiological evidence of extraocular muscle entrapment
4. Enophthalmos of more than 2 mm
5. Large fractures involving the floor of the orbit (more than 50% of the floor is involved)
6. Infraorbital nerve hypoaesthesia / anesthesia
7. Presence of oculo cardiac reflex (common in trap door type of fracture). Surgical repair should be performed immediately in these patients.

Surgical repair should be delayed:

1. When there is presence of hyphema
2. Ocular rupture
3. Extensive oedema

Causes of ocular motility disturbances:

1. Intraorbital tissue hemorrhage – usually resolves during the first week of injury
2. Intraorbital tissue oedema – resolves during the second week of injury
3. Entrapment of extraocular muscles
4. Entrapment of orbital fat
5. Direct damage to extraocular muscles – causes adhesions and scarring within two weeks of injury. This stage should be considered to be point of no return as surgical results are poor.
6. Direct damage to nerve supply of extraocular muscles
7. Direct damage to blood supply of extraocular muscles

Blow out fracture involving orbital floor:
This is the commonest type of blow out fracture encountered. The floor of the orbit is divided in to medial and lateral segments by the Infraorbital nerve. The segment of the floor medial to the nerve is larger and more fragile, hence is commonly involved in blow out fractures.

Boundaries of medial segment of orbital floor:

1. Inferior orbital fissure – posteriorly
2. Bony canal of Infraorbital nerve – laterally
3. Orbital rim – anteriorly
4. Inferior aspect of lamina papyracea (Laminar bar) – medially

Lateral segment of the floor of orbit:

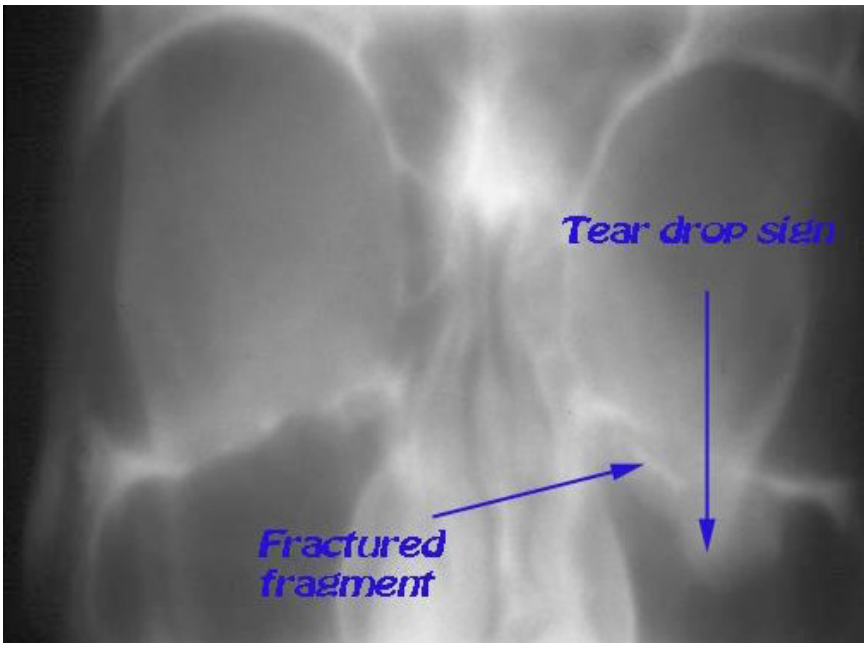
This segment is smaller, thicker and stronger than the medial segment of orbital floor. Fractures involving this segment are pretty rare.

Clinical photograph of a patient with blow out fracture

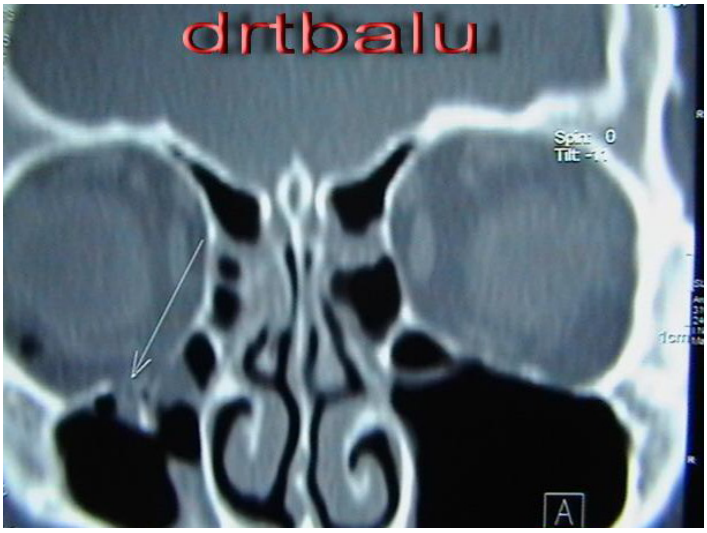
Classification of orbital floor fractures:

According to fracture patterns, fractures involving orbital floor may be classified into three types. This classification helps in deciding the optimal management modality.

1. Trap door type – This type of fracture occurs when a large fragment of the medial floor of the orbit is fractured and remains still attached to the laminar bar medially. This fracture resembles a trap door hinged at the laminar bar (lamina papyracea).
2. Medial blow out – This type of fracture occurs when there is bone disruption between the laminar bar and the Infraorbital nerve.
3. Lateral blow out – This type of fracture causes a comminution from the laminar bar to the lateral orbital wall.



X -ray paranasal sinuses: May show the classical “tear drop sign” of prolapsed orbital contents. The fractured fragment may also be visible. The corresponding maxillary sinus may appear hazy due to the presence of hemosinus.



CT (coronal) showing blow out fracture

Blow out fracture involving the medial wall of orbit:

Fractures involving medial wall of orbit may occur alone or as part of more complex orbital fractures. Pure medial wall fractures are really rare. Fractures involving medial orbital wall may be missed in plain radiographs, hence CT scan is diagnostic.

Clinical features of fracture medial wall:

1. Periorbital oedema
2. Ecchymosis
3. Subcutaneous emphysema due to escape of air from ethmoid sinus in the periorbital space
4. Epistaxis
5. Enophthalmos – According to Pearl enophthalmos is worse in medial blow out fractures than fractures involving other walls of orbit.

Classification of medial wall of orbit:

Type I – Pure medial wall of orbit fracture
Type II – Medial wall and floor of orbit fracture
Type III – Fractures involving medial wall, floor of orbit and trimalar fracture
Type IV – Fractures involving medial wall, floor of orbit, maxillary, naso orbital, and frontal bones

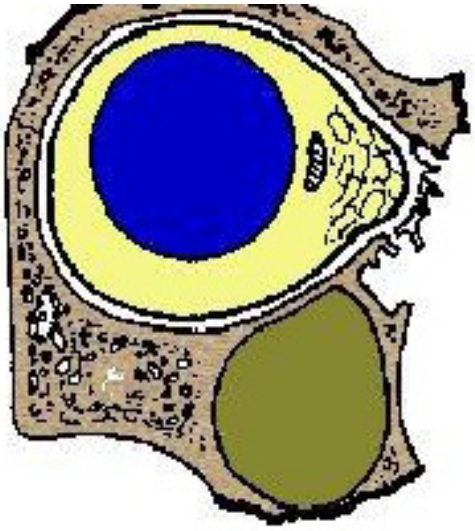


Figure showing type I fracture of medial orbital wall

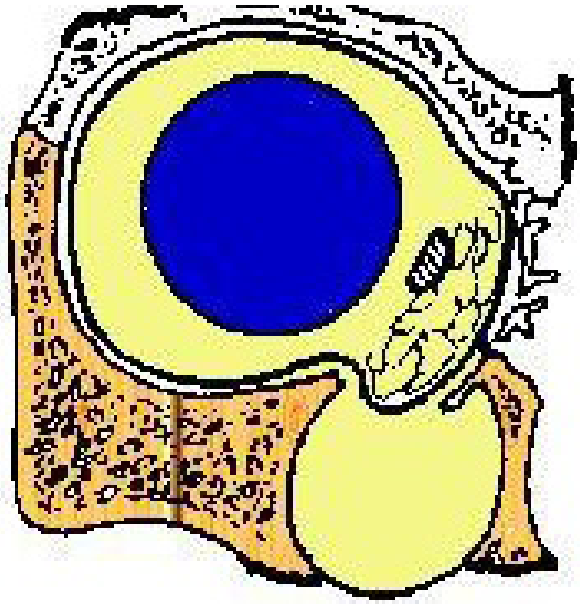


Figure showing type II fracture of medial orbital wall

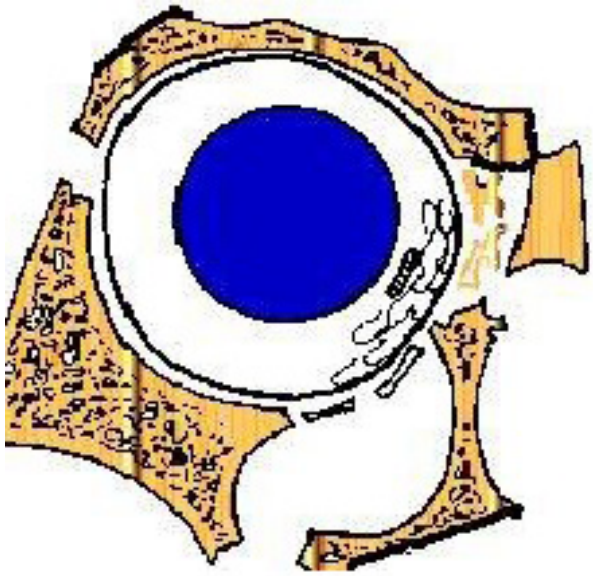


Figure showing type III fracture of medial orbital wall

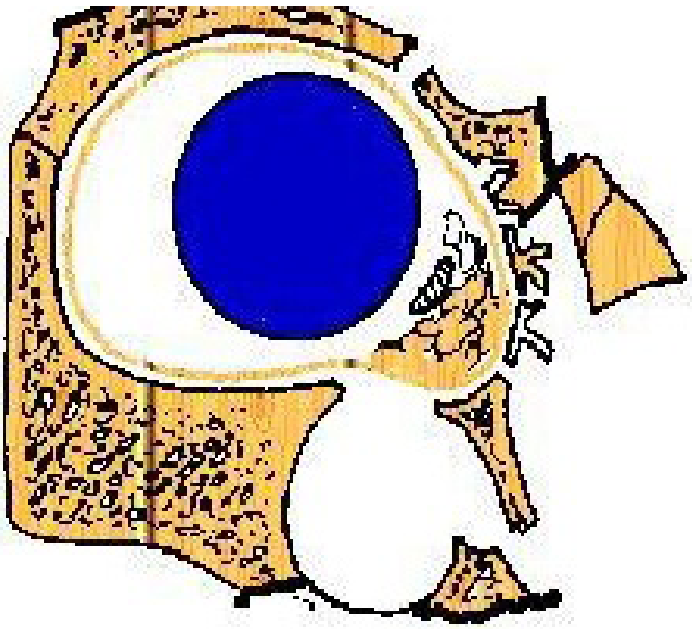


Figure showing type IV fracture of medial orbital wall

These classification systems are based on CT scan findings. Type I medial orbital wall fractures are commonly caused by assault, while other types of fractures are caused by road traffic accidents.
Visual disturbances were commonly seen in type I, II, and III fractures involving the medial wall of orbit, and is very rare in type IV fractures.
Eye ball injuries are common in type II fractures of medial wall.

Diplopia and enophthalmos are commonly seen in type II fractures.
Displacement of orbital walls and herniation of soft tissues were quite high for type I, type II and type IV injuries. It is very uncommon in type III injuries, suggesting that when there is associated malar fracture then the fragments are more linear without any displacement.
Type I fractures can be repaired using fronto ethmoidal lesion / Lynch Howarth and reduction of prolapsed orbital contents and supporting the wall using Marlex mesh, whereas other types of fractures involving medial orbital wall can be repaired by subciliary / transconjuctival approaches.

Fractures involving lateral orbital wall:
Fractures of lateral orbital wall is always associated with fractures of zygoma and malar complexes. This fracture is common in adults and is very rare in children. This fracture should be suspected in all patients who have severe facial injury. Imaging is a must not only for diagnosis but also to decide the optimal management modality.

A brief review of anatomy of lateral orbital wall wont be out of place here. The lateral orbital wall is formed by the zygomatic bone anteriorly. This bone is responsible for mid face prominence. The posterior wing of sphenoid forms the posterior portion of the lateral orbital wall along with the anterior corner of the middle cranial fossa. Fractures involving the greater wing of sphenoid is very rare. Articulation between the zygomatic bone and greater wing of sphenoid is very broad and is the commonest site in fractures involving lateral orbital wall. Fractures involving lateral wall of orbit is also associated with disruption of zygomatic bone articulations with frontal, temporal and maxillary bones.

Clinical features:

1. These patients have varying degrees of mid face deformities
2. Displacement of lateral orbital wall has a dramatic effect on the position of the eye. The lateral orbital rim is approximately at the equator of the globe. Infro lateral displacement of the lateral orbital wall will have significant change in the postion of the orbit when compared to that of simple infraorbital floor blowout fracture.
3. Visual loss may occur due to injury to the optic nerve. Whenever there is visual loss then retrobulbar hemorrhage, penetrating foreign body or bony fragment impinging on the optic nerve should be considered.
4. Lateral canthal dystopia
5. Ecchymosis
6. Subconjunctival hemorrhage

Axial and coronal CT scans should be taken in all these individuals.

Management:

Repair of open globe injuries takes precedence over fracture reduction. In patients with globe injuries fracture reduction can always be delayed. If intraocular pressure is found to be very high, bedside lateral canthotomy / cantholysis should be performed immediately to reduce the tension. If done immediately this procedure will save vision in a majority of these patients.
If the orbit appears tense and tight surgical evacuation of orbital hematoma should be resorted to.

Specific management of these fractures are dependent on the following factors:
1. Degree of displacement of fractured fragments
2. Comminution of fracture
3. Intracranial extension of sphenoid fracture

Non displaced / mildly displaced fractures can be managed conservatively. If fracture causes displacement with visual loss / ocular motility disturbance, enophthalmos, flattening of malar eminence fracture repair is indicated. Before actually embarking on surgical repair preexisting corneal incision wounds need to be evaluated for possible leak during surgery. Although there may not be significant elevation of intra ocular pressure aqueous fluid may leak through preexistent corneal wounds causing collapse of the globe. It always pays to repair corneal wounds if any before the actual reduction procedure.
Before surgery a forced duction test should always be performed to rule out intraocular muscle entrapment.

Lateral upper eyelid crease incision can be used to expose zygomaticofrontal suture line. Infraorbital rim can be exposed via transconjuctival / subciliary incisions. Zygomaticomaxillary buttress can be accessed via buccogingival incision. To reduce comminuted fractures of zygoma a temporal / coronal incision may be used.

Use of resorbable plates and screws is advisable in young children who have actively growing bones. For non comminuted fractures of zygoma a two point fixation with titanium miniplate is advisable. The first point is ideally in the infra orbital rim and the second point over the frontozygomatic suture line is desirable.

Orbital roof fractures:

Orbital roof fractures always occur together with that of frontal roof fractures. It can cause diplopia due to intraocular muscle entrapment. These patients may also present with enophthalmos / exopthalmos. The commonest cause of diplopia in these patients is the entrapment of connective tissue around superior rectus within the fractured bony fragments. It is just sufficient if this entrapped tissue could be freed by endoscopically removing the fractured bony fragments.

Surgical approach to orbit:

Orbital cavity can be accessed by various surgical approaches. These approaches can be classified according to the area of orbit that becomes accessible.
1. Approaches to lateral wall and orbital roof
2. Approaches to medial wall of orbit
3. Approaches to the floor of the orbit

Approaches to lateral wall and orbital roof include:

a. Lateral brow incision
b. Upper blepharoplasty incision
c. Coronal incision
Lateral brow incision: Is suited for exposing frontal and zygomatico sphenoid sutures. The lateral portion of the superior orbital rim is also exposed well by this incision. The brow incision is placed just below the hair follicles of lateral 2-3 cm of the upper eyebrow.

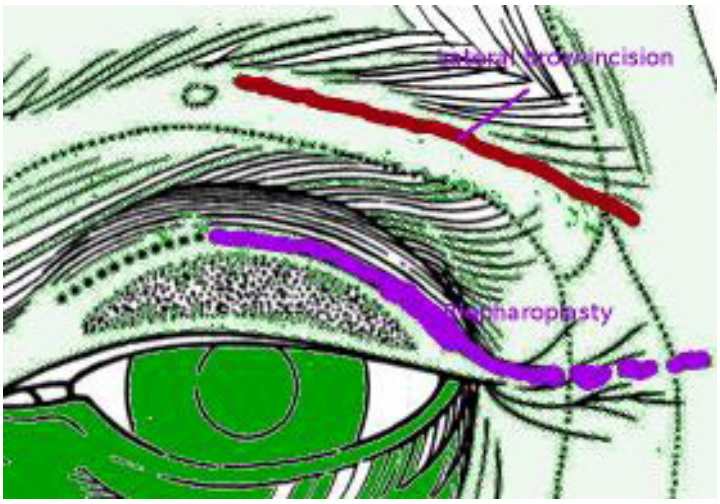


Figure showing lateral brow incision and blepharoplasty incision

Before placing the incision lateral brow approach xylocaine is infiltrated inferior and parallel to the lateral border of the upper eyebrow. Incision is made just below the upper eyebrow with 15 blade. The incision is deepened and carried through skin and orbicularis oculi. The periosteum over lateral orbital rim is sharply dissected and elevated using a Freer's elevator.
Major disadvantage of this approach is the scarring which takes place. That is the reason why upper blepharoplasty approach became popular.

Upper blepharoplasty:
First the supratarsal fold is marked. It is typically 8-9 mm above the ciliary line.
Xylocaine with adrenaline is injected subcutaneously, down to the lateral orbital rim at the zygomaticofrontal suture. Skin is incised, and the underlying orbicularis oculi muscle should be divided parallel to its fibers. This is ideally done using scissors. Dissection is then performed in a plane superficial to the orbital septum and lacrimal gland, until the lateral orbital rim and zygomaticofrontal suture as needed.
The advantage of this approach is the cosmetically acceptable scar.

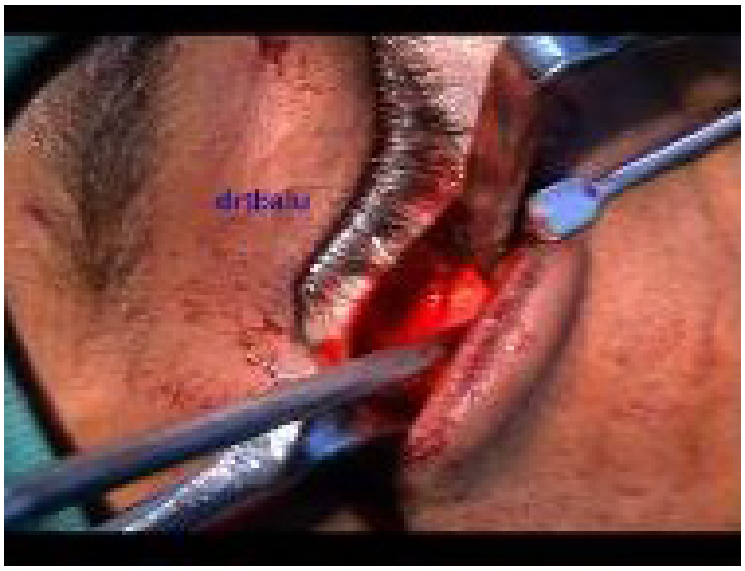
Coronal approach:
This approach provides excellent access to medial, superior and lateral walls of orbit, as well as the zygomatic arch. It gives excellent access to both orbits and dorsum of the nose.
The coronal incision begins at the upper attachment of helix and extends transversely over the skull vault to the opposite side. The incision slightly curves forwards over the vertex of the skull just behind the hair line. This incision can also be extended to the preauricular area to expose the zygoma and zygomatic arch. The line of incision should be marked previously and infiltrated with xylocaine mixed with 1 in 100,000 units adrenaline. The flap is raised leaving the periosteum intact. Raney clips (liga clips) are applied to the edges of the flap to secure hemostasis.
The periosteum is incised about 3 cm above the supraorbital ridges, and the dissection should be continued in the subperiosteal plane. Care should be taken to release the supra orbital neuro vascular bundles from the notch / foramen. This subperiosteal dissection is continued inferiorly till naso ethmoidal and naso frontal sutures are exposed. Laterally the dissection follows the outer layer of temporalis fascia till about 2 cms above the zygomatic arch. At the level of the arch of zygoma the temporalis fascia splits to enclose temporalis muscle. At this point an incision which runs antero superiorly at 45 degrees is made over the superficial layer of temporalis fascia. This is done to spare the frontal branches of facial nerve. This incision is connected anteriorly with the lateral or posterior limb of the supraorbital periosteal incision.

The plane of dissection deep to the superficial layer of temporalis fascia is carried inferiorly till the zygomatic arch is reached. The periosteum in this area is incised and reflected over the zygomatic arch, zygoma, and lateral wall of orbit. After satisfactorily reducing the fracture the wound is closed in layers.

Disadvantages of this approach:
1. Extensive incision
2. Alopecia
3. Numbness of forehead area
4. Injury to temporal branch of facial nerve

Surgical approaches to orbital floor have been classified into:
1. Transorbital – Transcutaneous, Transconjunctival and subciliary approaches
2. Transantral – includes endoscopic approach
3. Combined approach

Transcutaneous orbital rim incision is usually given just below the lower eyelid. This approach is very simple one and easy to perform. The incision area is marked and infiltrated with xylocaine mixed with 1 in 100,000 units adrenaline. Ideally the incision should hug the infra orbital rim. Orbicularis oculi muscle should be slit along its long axis. Orbital contents are retracted to expose the floor of orbit. This approach gives rise to post operative oedema. This incision also causes visible scar just below the lower eyelid.



Picture showing transcutaneous incision for orbital floor exposure

Subciliary / Subtarsal approaches to orbital floor:

Converse originally described this incision as an approach to orbit in 1944. He was also instrumental in devising a variant of this incision i.e. subtarsal approach. Both of these incisions are types of transcutaneous incision. For this incision local anesthesia mixed with adrenaline is infiltrated subcutaneously into the lower eyelid along the infra orbital rim. A lateral temporary tarsorhaphy is performed to protect the orbital contents during the procedure. A subciliary cutaneous incision is made 2mm below and parallel to the eyelash line. This incision is usually performed using a 15 blade. Medially this incision should fall short of the punctum, while laterally it can be extended even up to 15 mm beyond the lateral canthus. The lateral extension of this incision is preferred should be extended horizontally and not inferiorly in order to promote formation of aesthetically acceptable scar. Dissection proceeds in the subcutaneous plane superficial to orbicularis oculi muscle. At the level of lower end of tarsal plate orbicularis oculi muscle is divided parallel to the direction of muscle fibers. Orbicularis oculi muscle over the tarsal plate should be protected to maintain lower lid structure and support. The dissection now follows the preseptal plane down to the level of orbital rim. The periosteum is incised over the anterior portion of infraorbital rim. This elevation of the periosteum proceeds up to the level of orbital floor.

In subtarsal variation of this procedure the incision is sited in the subtarsal fold about 5-7 mm below the eyelash line. After repair a Frost suture is applied to support the lower eyelid.

Advantages of this approach:

1. Easy to perform
2. Gives broad access to the floor of orbit

Disadvantages include:

1. Lower lid malposition
2. Scarring of lower eyelid

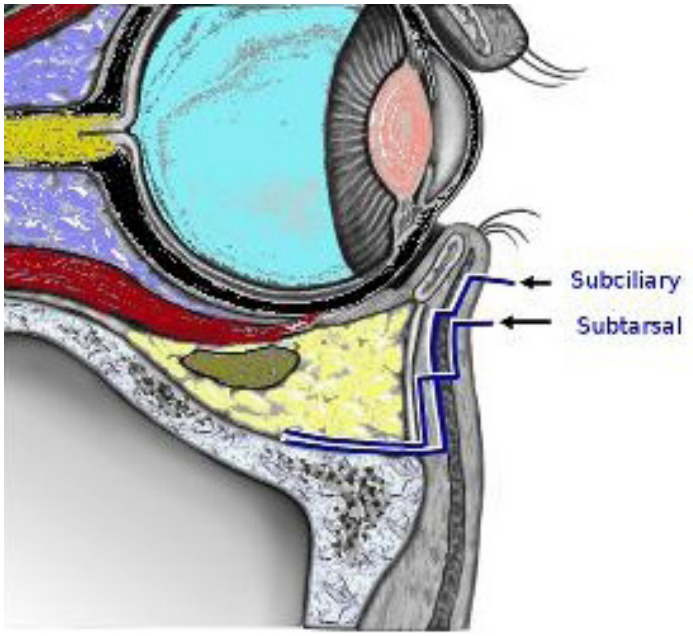


Figure showing subciliary and subtarsal approaches

Transconjunctival approach to orbit: This method was popularized by Tessier. Converse etal reported treating a series of patients with blow out fracture involving the floor of the orbit using this incision. This is the most preferred approach for orbital surgeries because of low complication rates and excellent cosmesis. In this method the lower eye lid is pulled forward. To increase the laxity a lateral canthotomy should be performed.

Lateral canthotomy: is performed by incising the skin, subcutaneous tissue and orbicularis oculi muscle horizontally. The incision should ideally be sited in the skin crease of the outer canthal region. The lateral canthal tendon is visualized and its inferior limb alone is severed.

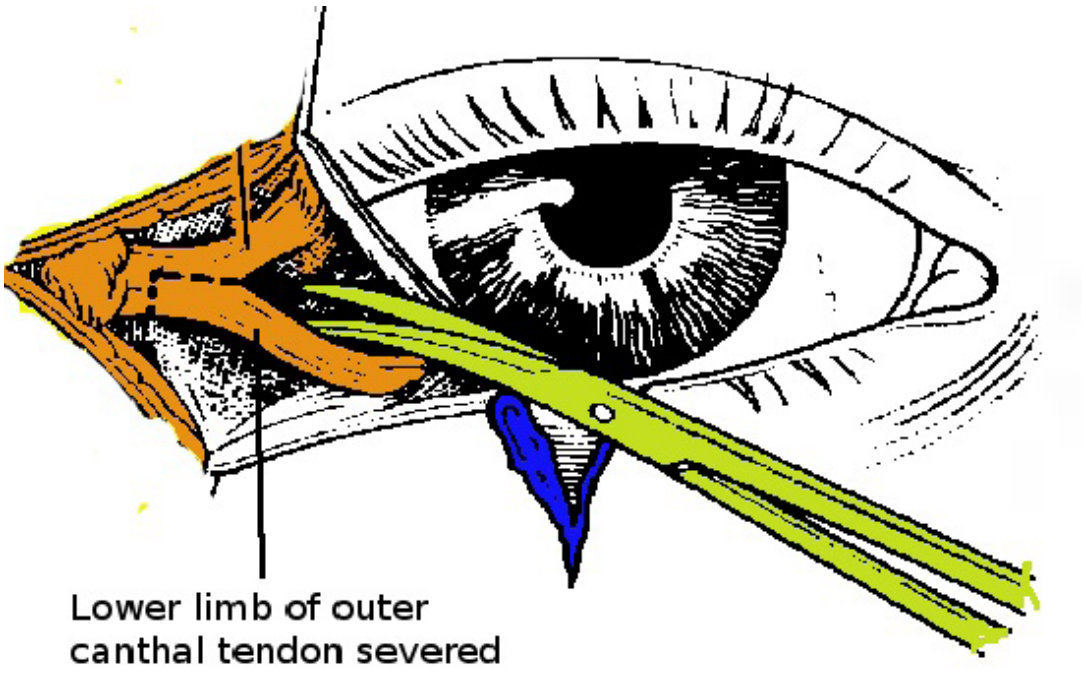


Figure showing canthotomy being performed

Two methods can be performed via this incision. 1. Preseptal method and 2. Retroseptal method.
Preseptal method: In this method incision is made at the edge of the tarsal plate to create a space in front of the orbital plate to reach the orbital rim. The floor of the orbit is reached by dissecting the Muller's muscle and the eyelid fascia. Dissection then proceeds between orbital septum and orbicularis oculi muscle. The periosteum lining the infraorbital rim should be excised and dissected to expose completely the floor and lateral wall of the orbit if necessary.

Retroseptal method: In this method an incision is sited 2mm below the tarsal plate to reach the orbital rim.
Either of the above methods grants access to the floor of the orbit. Mild retraction is applied to the globe to visualize the floor of orbit fully. Prolapsed orbital contents can be pushed back into orbit and the defect can be closed using appropriate prosthesis.

The major advantage of this procedure is there is virtually very minimal scar formation. It is very quick to perform and involves no skin, muscle dissection. Dissection in the plane of orbital septum is avoided, hence there is very minimal chances of vertical shortening of lower eyelid. The only disadvantage is the limitation of access to the medial portion of the orbital floor.
In cases of blow out fractures involving the medial portion of the floor of the orbit Caldwel luc procedure can be performed to reduce the fracture fragment. Nasal endoscope can be introduced through the caldwel luc fenestra to improve visualisation.

The prolapsed orbital contents are freed and reduced. Fractured fragments repositioned if possible and stabilized using plate and screws. If defect is large prosthesis can be utilized to stabilize the orbital floor.

Figure showing transconjunctival incision marked out

Complications of transconjunctival approach to orbital floor:

1. Eye lid avulsion
2. Button holing of lower eyelid
3. Canthal dehiscence
4. Cicatricial ectropion
5. Entropion
6. Lower eyelid retraction
7. Scleral show
8. Hematoma
9. Prolonged chemosis
10. Lacrimal sac laceration

Factors that can cause problems with transconjunctival approach:

1. Approach to the medial wall of orbit
2. Proptosis / orbital swelling
3. Severe chemosis
4. Severe swelling of lower eyelids
5. Laceration / trauma to conjunctiva

Protection of cornea is another vital aspect in avoiding complications in transconjunctival approaches. This can be achieved by:
1. Placing plastic corneal shield
2. Use of Jaeger retractor which protects the cornea while retracting the orbit

Placement of incision – This is also vital in avoiding complications.
The incision should ideally be placed between the lower border of tarsus and the fornix. This incision avoids injury to the tarsal plate and also prevents scarring of the orbital septum. Efforts should be taken to prevent undue tissue damage in this area as scarring in this area will lead to a lot of problems later. Majority of the complications of this procedure is caused by scarring that occurs in this area due to excessive tissue damage. Unipolar cautery when used to make conjunctival incision should be used in the lowest possible setting. Laceration and conjunctival tears should be avoided.

While performing lateral canthotomy lysis of the superior crus of lateral canthus should be avoided. Only the inferior crus should be lysed. Moreover while performing lateral canthotomy excessive incisions of conjunctiva should be avoided.

It has been shown proper canthotomy avoids excessive traction of lower eyelid during surgery, thus prevents lid lacerations.

Technical aspects of conjunctival closure:
Granulations have been found to occur when there is improper healing of conjunctival suture line. This eventually leads to scarring of fornix. To avoid this complication limited closure of conjunctiva has been resorted to. Only two sutures are given using 6 – 0 catgut on either side of limbus. Any extra sutures given always leads to problems of granulation in the area.

Resuspension of inferior canthal tendon:
This is another important step in transconjuctival procedures where lateral canthotomy has been resorted to. If not performed properly canthal migration has been known to occur in the inferior direction. It is always better to use permanent suture materials like Teflon impregnated braided polyester suture material to suspend the inferior canthal tendon. In case extensive dissection was performed to expose the lateral wall of orbit by stripping orbital periosteum in that area, the inferior canthal tendon should be secured to the lateral bony wall of orbit by using 30 gauge wire. This will prevent canthal migration in these patients. If both superior and inferior crura of lateral canthal tendon were excised during surgery then reconstruction gets a bit complicated. In these patients the inferior crus must be reattached to the lateral orbital wall just posterior and superior to Whitnall's tubercle. This is usually done by using 30 gauge wires. Then only should the superior crura should be reattached.

Reconstruction of lateral canthal angle:

This is another aspect of repair that should be taken note of. After securing the inferior crura of lateral canthal ligament reconstruction of lateral canthal angle must be resorted to. This is usually performed using absorbable sutures taking care to line up the anatomic eyelid markers.

Resuspension of orbicularis muscle:

This is the next step that should be carefully performed. The orbicularis muscle which was elevated off the lateral orbital periosteum should be resuspended carefully using 4-0 absorbable sutures. Usually it is resuspended in an over corrected position. This is done to allow for change in position due to fibrosis.

Frost stitch:
This stitch is usually used to splint the lower eyelid during the period of repair. This is usually a must in patients with excessive chemosis / proptosis. This stitch is usually placed through the lower eyelid and suspended from the forehead with the help of a tape atleast for a period of three days following surgery. This provides excellent splinting to the lower eye lid during this crucial phase of healing.

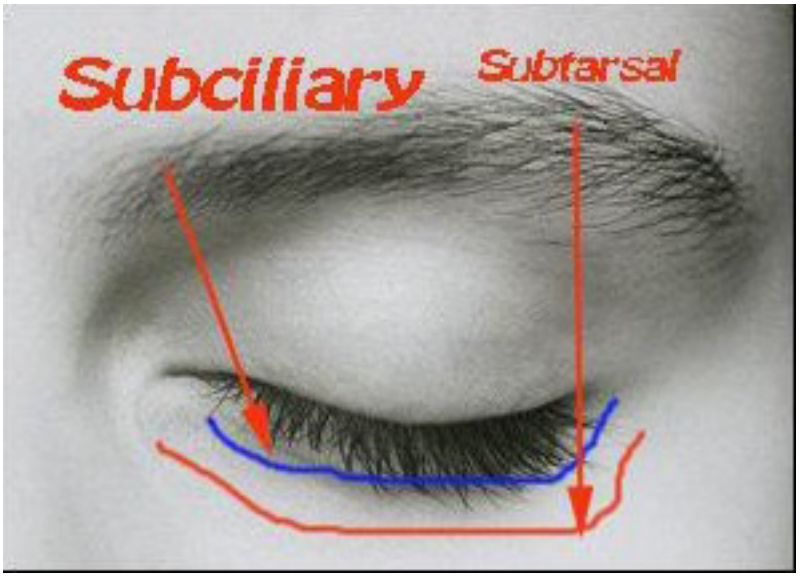


Figure showing subciliary and subtarsal incisions marked

Endoscopic reduction / repair of blow out fracture:
Indications:
They are more or less identical to that of traditional repair procedures. Indications include:
1. Isolated fractures involving the floor of the orbit with extraocular muscle entrapment.
2. Preoperative Enophthalmos
3. More than 50% disruption of orbital floor
4. Trap door and medial blow out fractures of floor of orbit respond the best to Endoscopic repair

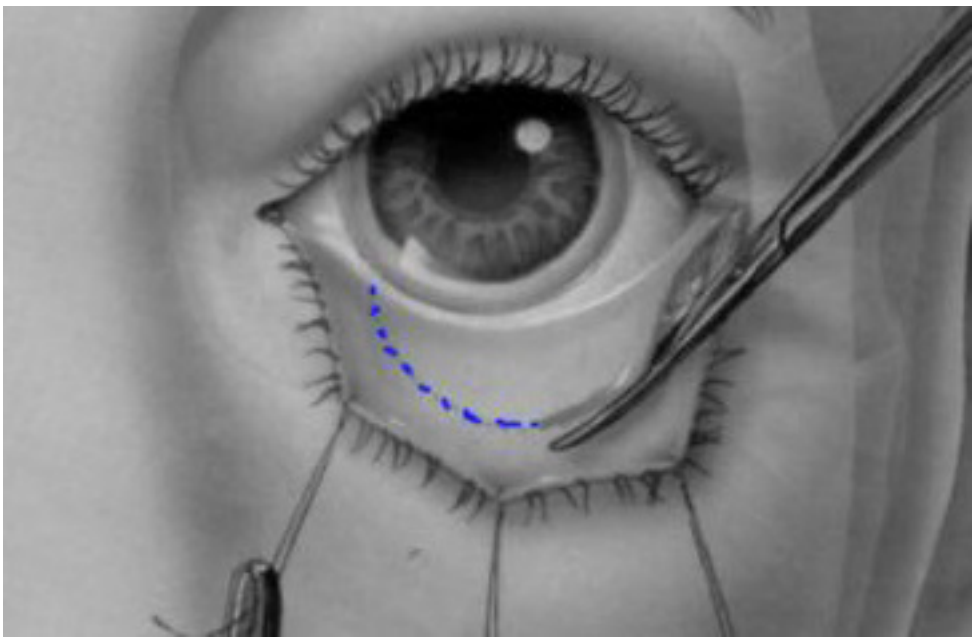


Figure showing incision for Transconjunctival approach

Endoscopic reduction / repair of blow out fracture:
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4. Trap door and medial blow out fractures of floor of orbit respond the best to Endoscopic repair

In lateral blow out fractures of orbital floor Endoscopic repair will jeopardize the Infraorbital nerve as extensive dissection is necessary in that area.

Procedure:
Primary surgeon if he is right handed should stand to the right of the patient. The table is usually turned 180 degrees from anesthesia equipment. The assistant surgeon and the nurse should be on the left side of the patient. Monitor should be placed at the head end of the patient. Both the surgeon and his assistant should have an unobstructed view of the monitor.

Incision:
The upper buccal sulcus on the side of injury is infiltrated with 2% xylocaine mixed with 1 in 100,000 units adrenaline. This infiltration helps in elevation of soft tissue and periosteum from the anterior portion of the maxilla. It also has the added advantage of minimizing bleeding. A 4 cm sub labial Caldwell incision is given in that area exposing the anterior wall of the maxilla. Dissection is performed in a subperiosteal plane up to the level of Infraorbital foramen. Excessive traction should not be exerted in the Infraorbital nerve area.
A 4 mm antrostomy is performed over the canine fossa are. This is the thinnest portion of the anterior wall of the maxilla. Boundaries of canine fossa include:

1. Canine eminence medially
2. Maxillary tuberosity laterally
3. Infraorbital foramen superiorly
4. Superior alveolar margin inferiorly

The antrostomy is widened using kerrison's rounger. Final dimensions of antrostomy should at least be 1 x 2cms and should lie about 2mm below the Infraorbital foramen. When enlarging the antrostomy care must be taken not to injure dental roots, Infraorbital nerve and the nasal aperture. As an alternative a bone saw can be used to remove a 1 x 2 cms plate of bone from the canine fossa area and can always be plated back in position after surgery is over. This procedure is considered more anatomical as the area of surgery is reconstructed.
A retractor is used to retract the upper lip. Ideally a Greenberg retractor is best suited for the procedure because of its self retaining nature. If not available a Langhan's retractor can also be used. Caution should be exercised while retracting the upper lip in not causing excessive traction to the Infraorbital nerve.

A 30 degree endoscope is introduced through the antrostomy with the angulation facing upwards. The entire floor of the orbit can be studied. If necessary the maxillary sinus can be irrigated with saline via the irrigation sheath of the endoscope and sucked out clearing blood clots and other debris from the maxillary sinus cavity. This step will help in better visualization of the area of interest. The natural ostium of maxillary sinus can be located in the postero superior portion of the medial wall of the sinus. The infra orbital nerve could be seen as a while line running from the orbital apex to the Infraorbital foramen. It is imperative on the part of the surgeon to identify the maxillary sinus ostium and infra orbital nerve before proceeding further, in order to avoid injury to these structures.

Pulse test: This test is usually performed after completely visualizing the floor of orbit as well as the above mentioned vital intra sinus structures. This test is performed while the floor of the orbit is fully under Endoscopic view. Pressure is applied to eye ball causing mild displacement of the fractured floor of orbit. This can be visualized endoscopically to assess the dimensions of fracture as well as the extent of prolapse of orbital contents.

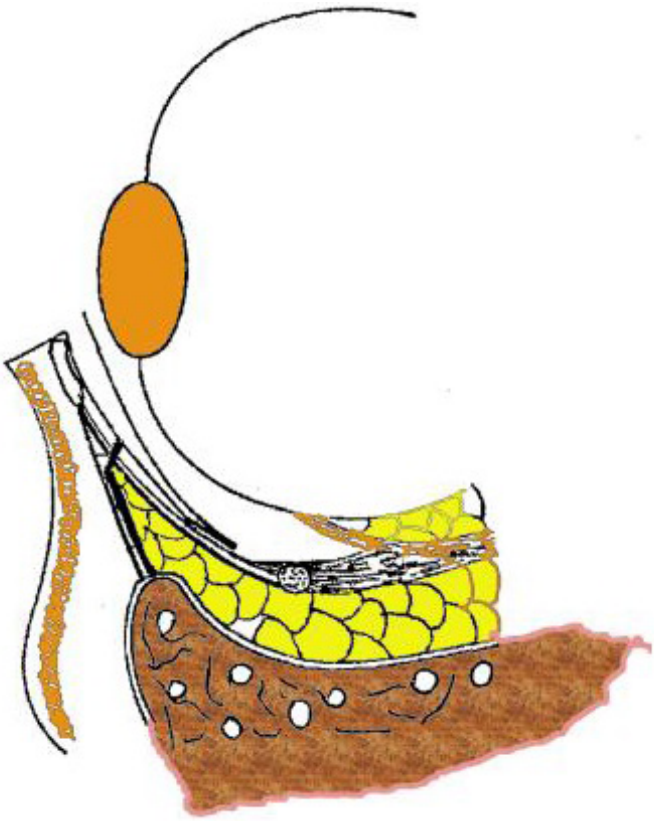


Figure showing plane of dissection in retroseptal transconjunctival incision

Endoscopic repair of trap door fracture:
In trap door fracture of orbital floor there is mild – moderate degree of orbital fat herniation. Strangulation of herniated orbital contents are common in these patients. This area appears endoscopically as enlarged and tense area. These fractures can be managed by reduction and repositioning of the fractured and displaced fragments. No prosthesis is necessary. As a first step in reduction of these fractures an angled elevator is used to expose 5 – 7 mm of maxillary sinus bone close to the lateral edge of the defect. Care is taken not to disrupt the mucosa over the hinge area as it would cause complete disruption of the fractured fragment. The lateral edge of the bone flap is retracted inferiorly; the orbital fat will immediately prolapse into the maxillary sinus. This fat tissue would have been entrapped within the fractured fragments of bone. A periosteal elevator is used to gently reduce the prolapsed orbital contents into the orbital cavity. The bone flap is hinged back into position. Care should be taken to ensure that this flap doesn't entrap orbital fat / Infraorbital nerve. Interfragmentary resistance maintains the reduction in place. If there is fragmentation of the lateral edge of the bony flap then Interfragmentary resistance may not be sufficient to maintain the bone flap in position. Then this procedure cannot be used and other methods of stabilization of fracture should be resorted to.

Keys to Endoscopic repair of trap door fracture include:

1. Meticulous dissection of lateral fracture margins
2. Minimal dissection over laminar bar, thus maintaining stability of the hinge region
3. Complete reduction of orbital contents

Endoscopic repair of medial blow out fracture: These fractures pose real challenges during Endoscopic reduction. These fractures are usually comminuted and unstable, hence requires more dissection and an implant for reconstruction of orbital floor. About 5 – 7mm of maxillary sinus mucosa should be dissected around the fracture taking care to protect the maxillary sinus ostium and the Infraorbital nerve. The entire circumference of the fracture should be visualized. Bleeding if any should be controlled using either oxymetazoline pledgets or adrenaline pledgets. All fractured fragments should be separated from the periorbita and removed. After defining the margins of fracture 3 – 5 mm dissection of the orbital surface of the defect is performed. This step releases the periorbita around the defect to accommodate the implant. After this step a greater degree of prolapse of orbital contents into the maxillary sinus cavity could be seen. This may seem to be worse than the pre op condition, but is to be expected. Silastic sheet of approximate size is introduced. The implant is resized and shaped according to the size of the defect by trial and error. It should be roughly 1.5 – 2 mm larger than the size of the defect. Orbital contents are gently reduced using a periosteal elevator and the implant is inserted. The implant is usually held in position by the orbital rim and the posterior bony shelf. The implant should ideally be positioned between the medial and lateral shelves. A pulse test should be performed to ensure that the implant is firmly in place. A forced duction test should also be performed to rule out orbital content entrapment.

Key points that must be borne in mind while managing Medial blow out fracture endoscopically:

1. The entire circumference of the defect should be visualized
2. All the fractured bone fragments should be removed because while inserting a prosthesis some of them may be pushed into the orbital cavity
3. Complete dissection and visualization of posterior shelf is critical
4. Medial fracture margin is difficult to define because it is oriented vertically, hence aggressive dissection in this area should be avoided.
5. The implant can be maintained in position by the anterior, posterior and lateral shelves

Postoperatively all patients should undergo CT scan to ensure that no orbital fat / contents are entrapped, and no bony fragments have been pushed into the orbit during placement of implant.

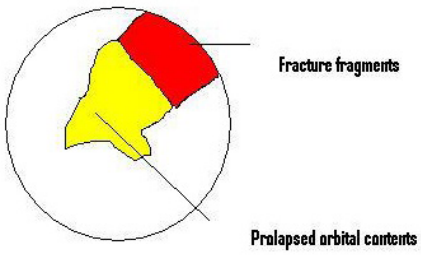
Patients with zygomatico - maxillary complex fractures also have orbital component injury. It should be borne in mind that there is a possibility of orbital floor fracture worsening after reduction procedures involving the zygoma component. All these patients must undergo Endoscopic examination of the orbital floor bearing in mind of this possibility. If there is also associated fracture of orbital floor then it should bee managed endoscopically.

Combined Transconjunctival – Endonasal – Transantral approach:
This approach is finding prominence in ophthalmology literature. Important drawback of this procedure is extensive removal of lateral nasal wall to facilitate Endoscopic visualization. With the introduction of 70 degree endoscopes removal of lateral wall can be minimized.

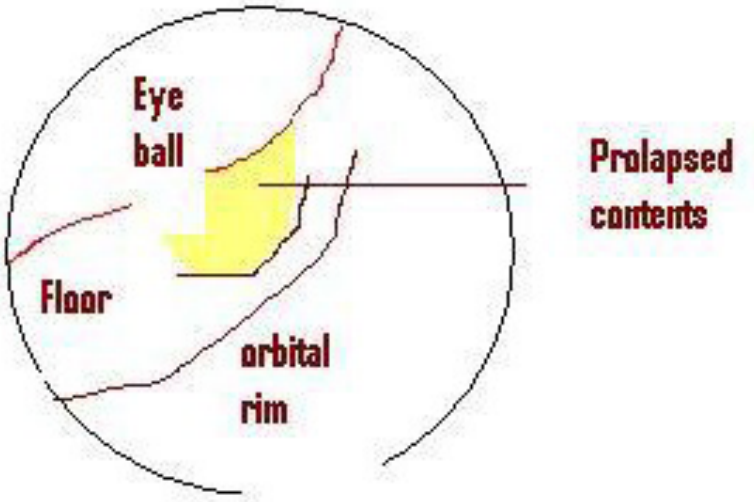
Procedure:
Patient is placed supine with head in a slightly elevated position. The nasal cavity is packed with 4% xylocaine and 1 in 10000 adrenaline. This helps in decongesting the nasal mucosa as well as reducing bleeding during surgery. Under Endoscopic guidance the lateral nasal wall is infiltrated with 2% xylocaine with 1 in 100,000 units adrenaline. The following structures should be removed:
1. Uncinate process
2. Ethmoidal bulla
3. Basal lamella
After removing these structures a partial posterior ethmoidectomy should be performed. The condition of medial orbital wall is examined. A gentle push to the eye ball can be seen as bulging of medial orbital wall through the nasal cavity. Similarly a gentle tug to the medial rectus muscle will help in identification of entrapment of medial rectus muscle within the fracture fragments (this is called forced duction test). If the orbital contents are found to be prolapsed through the defect in the medial wall of orbit, then it must be gently reduced. If forced duction test is positive then the entrapped extraocular muscle (medial rectus in this case) should be freed under Endoscopic vision.

The Natural ostium of maxillary sinus is enlarged both in the anterior and posterior directions. This is done in order to visualize the floor of the orbit through the maxillary antrum. A 70 degree 4mm nasal endoscope is used to visualize the interior of the maxillary sinus cavity. In case there is prolapsed orbital tissue / Infraorbital nerve then an incision is made in the palpebral conjunctiva just below the tarsal plate. Dissection can be pursued in the preseptal plane to reach the inferior border of the orbit. At the level of Infraorbital rim the periosteum should be incised to gain access to the floor of the orbit. On reaching the orbital floor the prolapsed tissue is reduced back into the orbit by dual approach (above and below via the maxillary antrum). Reduction via the maxillary antrum is performed under Endoscopic guidance. Orbital floor should be reconstructed if the defect is more than 2 cm. If there is Enophthalmos then medial wall of the orbit should also be reconstructed. Thin autologous iliac bone grafts are best suited for this purpose. The tissues can be held in position by inflated bulb of Foley's catheter placed inside the maxillary antrum and nasal packing. Merocel is the preferred nasal pack as it can be left in situ for more than 2 weeks without any fear of complications.

Caution: This approach is not suitable for small children with tooth buds in the anterior wall of the maxillary antrum.



Diagrammatic representation of Endoscopic view of fractured orbital floor via the maxillary antrum



Fracture of orbital floor as seen via Transconjunctival approach

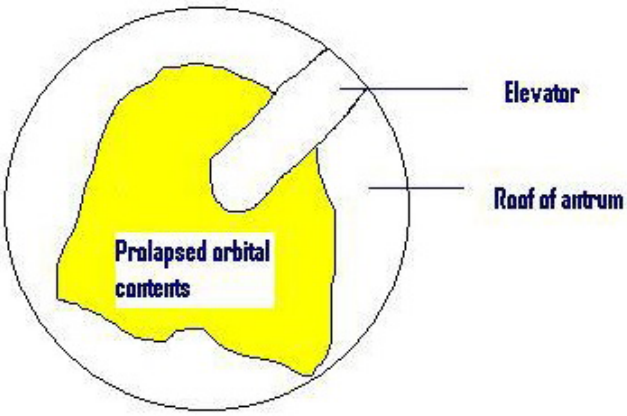


Figure showing orbital contents being reduced under Endoscopic guidance via maxillary antrum

Materials used for reconstruction of orbit:

1. Teflon sheets
2. Titanium meshes
3. Iliac bone crests
4. Septal cartilage
5. Biomaterials made from polylactide polymers

Preference of graft material depends on the surgeon's choice and his experience with using such prosthesis.
However ideal reconstruction material should have the following features:
1. Material should be thin, strong and light on weight
2. It should be easily cut and shaped
3. Once molded it should retain its shape
4. It should be radio opaque facilitating further radiological studies

Implant related complications include:

1. Infection and extrusion of implants
2. Displacement / migration of implants causing ectropion and diplopia
3. Lacrimal obstruction and epiphora
4. Capsular contracture over implants leading to pain
5. Presence of implant may lead to chronic smoldering inflammation delaying the process of normal healing

Advantages of titanium meshes as an implant material:
1. It is easy to trim and mould according to the dimensions of orbit. This feature is very pertinent when dealing with combined blow out fractures involving the floor and medial wall of orbit.
2. Its mesh like structure enables tissue to grow around it as well as through the pores. This affords a stabilizing effect to the graft material preventing its migration
3. It has excellent tensile strength even when cut to thin sizes. Hence can be safely used to bridge large defects of orbital floor
4. It can be sterilized by conventional means
5. It produces less artifacts in CT images

Draw backs of titanium mesh:
1. It is very difficult to remove in cases of infection as the tissue would have grown around and through the pores of the mesh.
2. It can migrate posteriorly towards the orbital apex causing further complications

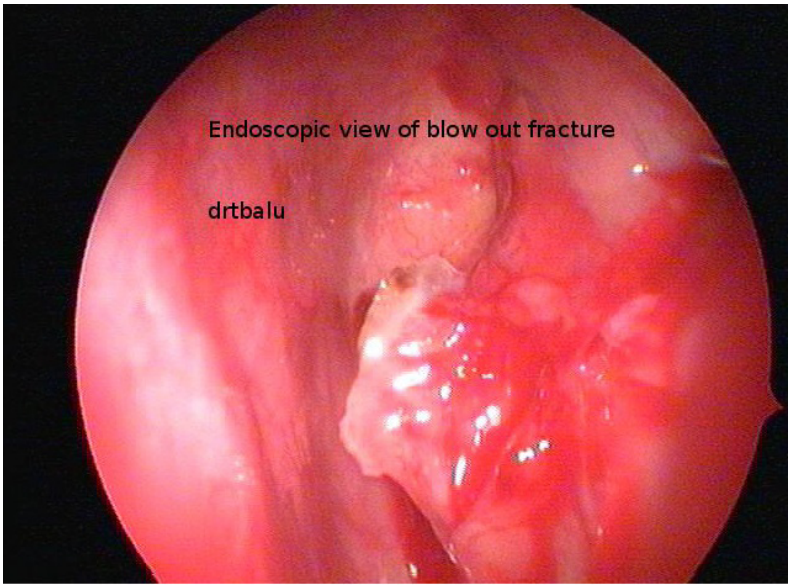
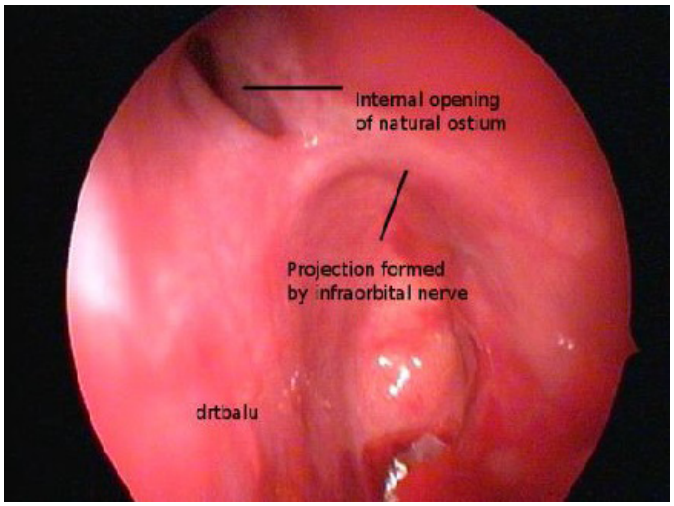


Figure showing endoscopic view of blow out fracture orbit



Endoscopic view of interior of maxillary sinus viewed from canine fossa

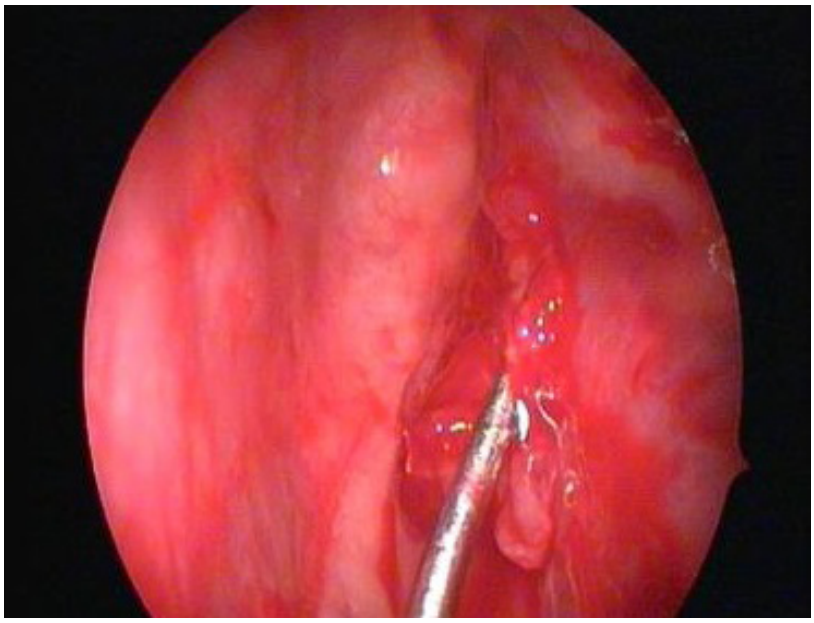


Figure showing blow out fracture being reduced

Bullard Laryngoscope

Introduction:

Bullard laryngoscope is a rigid fiberoptic laryngoscope which aids in visualization of larynx and intubation of trachea. Hence it is a very useful tool in the management of difficult airway. It uses fiberoptic technology and mirrors to look around the nook and corners of larynx.

Advantages of Bullard laryngoscope:

It is very useful during difficult intubation
Since it is designed to be inserted with the patient's head and neck in neutral position it can be used safely in patients with unstable cervical spine
It can be used in patients with mouth opening of just 6 mm
It can also be used for nasal intubation procedures
It can also be safely used in paediatric population also since it is available in adult and pediatric sizes

Situations tailor made for the use of Bullard laryngoscope include:

Patients with anteriorly placed larynx
Patients with unstable cervical spine fracture
Patients with upper body burns / trauma
Patients with temporomandibular joint immobility
Patients with micrognathia

Bullard laryngoscope is desgined in such a way that its blade is anatomically curved. At the proximal end an eye piece is provided. It is also provided with a fibreoptic power source attachments. It has two ports i.e. One for oxygenation / instilling medicines / suctioning and the other one for attachment of endotracheal tube stylet. Illumination is provided by fiberoptic light source.

The choice of the size of Bullard scope (adult / pediatric) is made taking into account the height of the patient and the minimal size of endotracheal tube that can be fitted into the stylet.

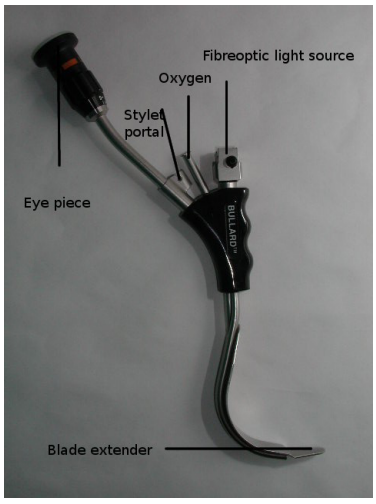
If the patient is 5 feet and less – pediatric size is preferred
If the patient is more than 5 feet but less than 6 – adult size preferred
If the patient is more than 6 feet tall – adult size with tip extender is used

Procedure:

If adult Bullard laryngoscope is used the tip / blade extender is securely snapped into the laryngoscope blade.
Select appropriately sized endotracheal tube. The endotracheal tube connector is removed temporarily and lubricant is applied over it.
The stylet is inserted into the endotracheal tube until it protrudes out of the endotracheal tube opening
When looking through the optical eyepiece only the stylet should be seen and not the tip of the endotracheal tube
Lubricant should also be applied to the Bullard blade also to facilitate easy insertion. Care should be taken to use only water based lubricants
Attach fiberoptic light source to the laryngoscope

Oral intubation:

Induction drugs are adminsitered to the patient as for regular intubation
Patient should be in neutral position
Place yourself as if you are performing direct laryngoscopy, the axis of the scope should be parallel to patient's axis
The scope is introduced between the teeth into the pharynx and is inserted as close to the midline as possible. The endotracheal tube should be held firmly in the nook of Bullard's laryngoscope while the whole assembly is being advanced.
When epiglottis is visualized, the handle of the Bullard laryngoscope is elevated straight up, the tip of the laryngoscope could be then seen retracting the epiglottis out of the way facilitating direct visualization of laryngeal inlet
The endotracheal tube is advanced over the stylet, and under direct vision is pushed into the trachea between the relaxed vocal cords
The stylet is detached and the scope is gently removed after ascertaining that the endotracheal tube is in place



Role of stents in Endoscopic Sinus Surgery

Introduction:

Formation of synechiae constitutes one of the common complications following ESS.Conservative estimates place about 10 % of all patients who have undergone ESS as prone forsynechiae. Dissection in the frontal sinus area is more prone for synechiae formation becauseof the difficult access. Dissection in this area is troublesome due to the difficult angleinvolved. True cutting instruments which cause little tissue damage have difficulty inreaching this area. Using powered shavers and debriders in this area has also not managed toreduce the risk of synechiae. Stents have been used with varying degree of success inpreventing postop complications following ESS.

Functions of Stents following ESS:

1. The primary function of stent is to separate two edges of raw wound thus preventingthe formation of fibrous band / synechiae. This is classically seen when there is lateralizationof middle turbinate following ESS. Lateralization of middle turbinate can potentiallyobstruct middle meatus drainage. This can effectively be prevented by placing a stentbetween the middle turbinate and the lateral nasal wall.

2. Stents can potentially take up space which would otherwise be occupied by mucous/ clot. Presence of clot can lead to epithelial migration and synechiae formation.

3. Patients in whom stents have been placed have very little crust formation, hencefrequent wound debridement is not needed.

4. Stents also serve as occlusal dressing facilitating better & faster wound healing.Occlusal dressings have known to reduce tissue necrosis.

Types of nasal stents:

1. Middle meatal stent
2. Frontal sinus stent
3. Drug containing stents

Middle meatal stents:

Role of middle meatal stents include:
1. Decrease synechiae formation
2. To prevent lateralization of middle turbinate
3. Since it fills up the ethmoid sinuses it effectively prevents clots, mucous or fibrin.

Stents of middle meatus is also known as spacers. Common spacers of middle meatus are made of glove fingers filled with polyvinyl acetyl sponge which are sutured together and tied with silk. Since this spacer is smooth it does not adhere to the surrounding tissue, thus serves as an occlusive dressing.

Foam made of biodegradable synthetic material like polyurethane can also be used to stent the middle meatus after surgery. This material is suitable for patients who does not tolerate other types of middle meatal stents.

Shikani stent:

This stent was designed by Dr. Alan Shikani of John Hopkin's university. It is a silicone stent with two flanges – one triangular which is used to separate the middle turbinate from the lateral nasal wall and the other smaller flange is used to secure the stent in the maxillary sinus. This stent can safely be left in place for more than 2 weeks. It is also safe for use in paediatric populations.

Image showing Shikani stent

Diagrammatic representation of Shikani stent in place

Shikani stent is available in 3 sizes.

Odisoft Rhino

Introduction:

Odiosoft rhino is an equipment used to measure the sound produced by nasal airflow. Measurement of nasal airflow sounds helps us to indirectly assess the presence / absence of nasal block as well as accurately identifying the site of the block. Normal nasal airflow in humans is neither laminar nor turbulent, but a mixture of both. Hence the term transitional is used to describe nasal airflow. Simple mathematical formulae cannot be used to study nasal air flow dynamics. At higer velocities of nasal airflow turbulence also increases. This turbulence creates sound which can be recorded by recording devices such as odisoft rhino.

Airflow within the nasal cavity is regulated by 4 valves:

External nasal valve
Internal nasal valve
Nasal turbiantes
Nasal septum

Role of Fourier analysis in the study of nasal airflow:

According to Fourier the French scientist any complicated wave form can be expressed as a series of two or more simple sine waves and cosine waves.

Sound generated by air passing through nasal cavity can be recorded by placing probes containing microphone in the anterior nasal cavity. These recorded sounds are subjected to fast fourier transformation using the software called Odisoft rhino.

The recorded frequency spectrum could be classified into:

Low frequency (500 – 1000Hz)
Medium frequency (1-2KHz)
High frequency (3-6 Khz)

Procedure:
Before emarking on recording nasal sounds, the following things should be ensured:
The patient should be completely relaxed
Crusts and mucous secretions from the nasal cavity should be removed
While testing the right nasal cavity the probe is held in the right hand and parallel to the right nasal cavity, while the left hand is used to close the left nasal cavity.
The probe should not be inserted into the nasal cavity and atleast 1 cm space should be there between the probe and the nares.
Recording usually starts during non forced expiration.
Recording should ideally be performed in quiet environment and acoustic artifacts like noise caused by rubbing of wires should be avoided.

Nasal sound analysis:

The frequency and amplitude of the recorded sounds should be taken into consideration. Nasal sound frequency and amplitude increases as the turbulence inside the nasal cavity increases. Nasal sound recordings in patients with deviated nasal septum have shown that the intensity of sound in lower and mid frequencies are not raised that much while the intensity of sound in high frequency was significanty elevated.
Obstruction in nasal valve area can be assessed by performing the Cottles Maneuver. Before cottle's maneuver the intensitey of sound in high frequency is elevated, while recordings performed during cottle's maneuver shows a reduction in the intensity of sound at high frequencies as the nasal air flow assumes a laminar pattern.

This whole system can also be used as a web based diagnostic service, where a patient can be asked to use the probe and the recorded sound is transmitted through internet to the diagnostic server where these sounds can be analysed and diagnosis can be made.

Nasal Mucosal Congestion Index

Introduction:

Nasal mucosal congestion is an important determinant in deciding whether the patient needs medical / surgical therapy. It goes without saying that if the nasal mucosa is thickened due to mucosal oedema than it would respond better to nasal decongestants, while if the thickening is due to underlying submucosal fibrosis then it doesn't respond to decongestants and needs to be surgically removed to improve nasal airway patency. Nasal mucosal compliance cannot be estimated by CT scans alone.

It has been demonstrated that tissue remodelling which is the repair response of nasal mucosa to insults is characterised by decrease in vascular density, and an increase in fibrosis causing the nasal mucosa to thicken irreversibly. This thickened mucosa reduces drug permeability through osmosis causing a reduction in the effectiveness of the drug.

Nasal mucosa congestion index:

This measurement helps in identifying mucosal oedema from mucosal thickening due to fibrosis involving submucosa. This can be measured by performing acoustic rhinomanometry before and after decongesting the nose with epinephrine. If the nasal mucosal congestion index is large then medical management is preferred and if the index is small then surgery should be resorted to in the management of chronic rhinosinusitis. For sake of objectivity congestion index of the nasal mucosa can be classified as normal, mild, moderate, severe and very severe.

Acoustic rhinometry:

This procedure was first introduced by Hilberg as an objective method in assessing the nasal cavity. This procedure is based on the principle that sound waves traveling through the nasal cavity is reflected by local changes in acoustic impedance. Four areas of the nasal cavity have been shown to be the cause of nasal resistance. They are:

1.Nasal valve area (internal nasal valve)
2.Nasal vestibule
3.Head of inferior turbinate
4.Head of middle turbinate

Nasal resistance caused contributed by these areas can be clearly assessed by acoustic rhinomanometry. This method is very accurate in studying the nasal resistance at the level of nasal valve area. The accuracy progressively reduces for nasal resistance contributed by posterior structures like head of the middle turbinate.

Thyroid Nodules and their Management

Introduction:

Thyroid nodule is a common occurrence. Majority of these nodules may be present without clinical evidence of thyroid disease. Statistics reveal that the incidence of palpable thyroid nodule is about 5%. Ultrasound neck is very sensitive in picking up thyroid nodules. Ultrasound can diagnose thyroid nodules even as small as ½ cm. Studies have shown that only 3-5% of thyroid nodules show malignant transformation.

Causes of thyroid nodules include:

Benign causes:
1. Goiter
2. Hashimoto's thyroiditis
3. Simple / hemorrhagic cysts
4. Follicular adenoma
5. Subacute thyroiditis

Malignant causes:

1. Papillary carcinoma
2. Follicular carcinoma
3. Hurthle cell carcinoma
4. Medullary carcinoma
5. Anaplastic carcinoma
6. Primary thyroid lymphoma
7. Metastatic malignant lesion

Tools of diagnosis as far as these thyroid nodules include:
1. Ultrasound neck
2. FNAC
3. Molecular / genetic marker analysis of fine needle aspiration biopsies

Clinical features:

Majority of thyroid nodules are incidental in nature. These nodules are commonly picked up during routine ultrasound of neck performed for some other problem. At this juncture it should be pointed out that carcinoma is common in single nodule than in multi nodular thyroid disease. A palpable neck node along with a firm thyroid nodule should always lead to suspicion of thyroid malignancy with nodal metastasis.

Palpation:

It is very difficult to pick out thyroid nodules less than 1.5 cm by palpation. The sensitivity of palpation varies from individual to individual. Moreover it is very difficult to palpate any nodule in a patient with thick and short neck. Nodules which are more than 4 cm are sinister. If these nodules are fixed to the skin and adjacent structures then extra glandular spread of malignancy will have to be suspected.

Features that point towards malignancy:

1. History of prior neck irradiation
2. Male gender
3. Extremes of age (20 & 70)
4. Family h/o medullary carcinoma thyroid / Multiple endocrine neoplasia
5. Growing nodule
6. Firm / hard nodule
7. Nodule with ill defined edges
8. Nodule that is fixed
9. Nodules associated with dysphonia / dysphagia / cough

Features in physical examination that could cause concerns of malignant transformation:

1. Thyroid nodules larger than 4 cms (20% risk of malignant transformation)
2. Firmness on palpation
3. Fixation of nodule to underlying structures
4. Cervical adenopathy
5. Vocal cord paralysis

Among the features listed above cervical adenopathy and vocal cord paralysis have the maximum predictive value for malignant transformation (up to 100%).
In patients with rapid enlargement of thyroid nodule a diagnosis of anaplastic carcinoma or primary lymphoma of thyroid should always be considered.

Growth of nodular goitre into the superior mediastinum can easily be identified by the presence of Pemberton's sign. This sign gets manifested because of partial occlusion of venous return from the thorax due to obstruction by the enlarging mass. This will be seen as enlargement of jugular vein and flushing of the face when the patient is asked to lift both the hands above the head. This maneuver further narrows the mediastinal outlet which is already compromised by the presence of enlarging thyroid mass.

Hormone status in patients with thyroid nodule:
Patients with thyroid nodule are usually euthyroid. It is always worthwhile to perform TSH estimation in these patients as a routine. If TSH values are reduced then T3 and T4 estimation should be performed since hyper functioning nodules are 10% common in patients with single nodule thyroid.

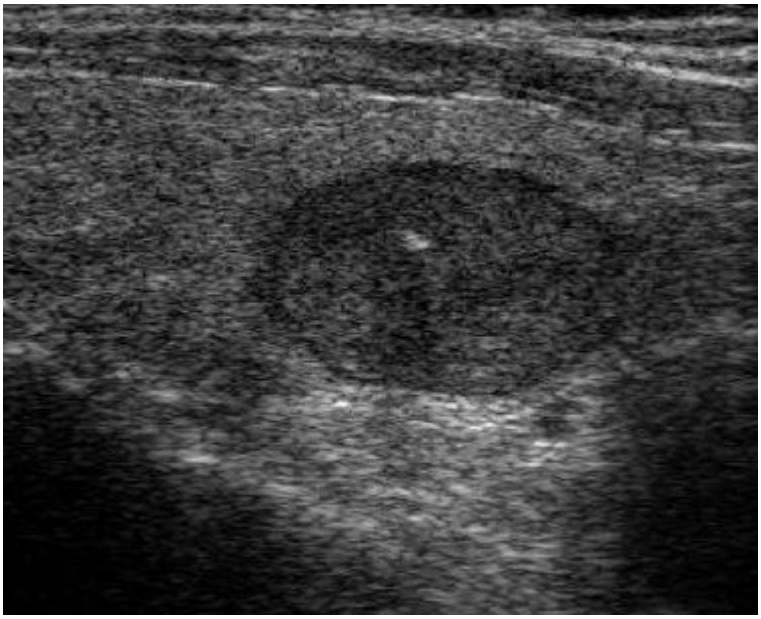
Estimation of serum calcitonin levels should be performed in all patients with solitary nodule thyroid with family history of medullary carcinoma thyroid / MEN types 2 a or b.

Role of ultrasound imaging in the diagnosis of thyroid nodule:

This is the most preferred imaging modality in evaluating a patient with thyroid nodule. It identifies even small nodules that cannot be palpated.

Advantages of ultrasound imaging:

1. It is very sensitive test which picks up even small nodules which cannot be palpated
2. Presence of multiple nodules can easily be identified.
3. Ultrasound can be used to assess the size of these nodules accurately and hence periodical scanning will pick up rapid increase in the size of these nodules
4. Certain features seen in ultrasound imaging points towards malignant transformation of the nodule. These features include solid mass (shown as hypo echoic areas), increased vascularity of nodules, presence of micro calcifications within the nodules, presence of irregular margins and absence of halo.
5. Ultrasound imaging is very useful in identifying suspicious nodules for performing FNAC



Picture showing ultrasound of benign nodule of thyroid

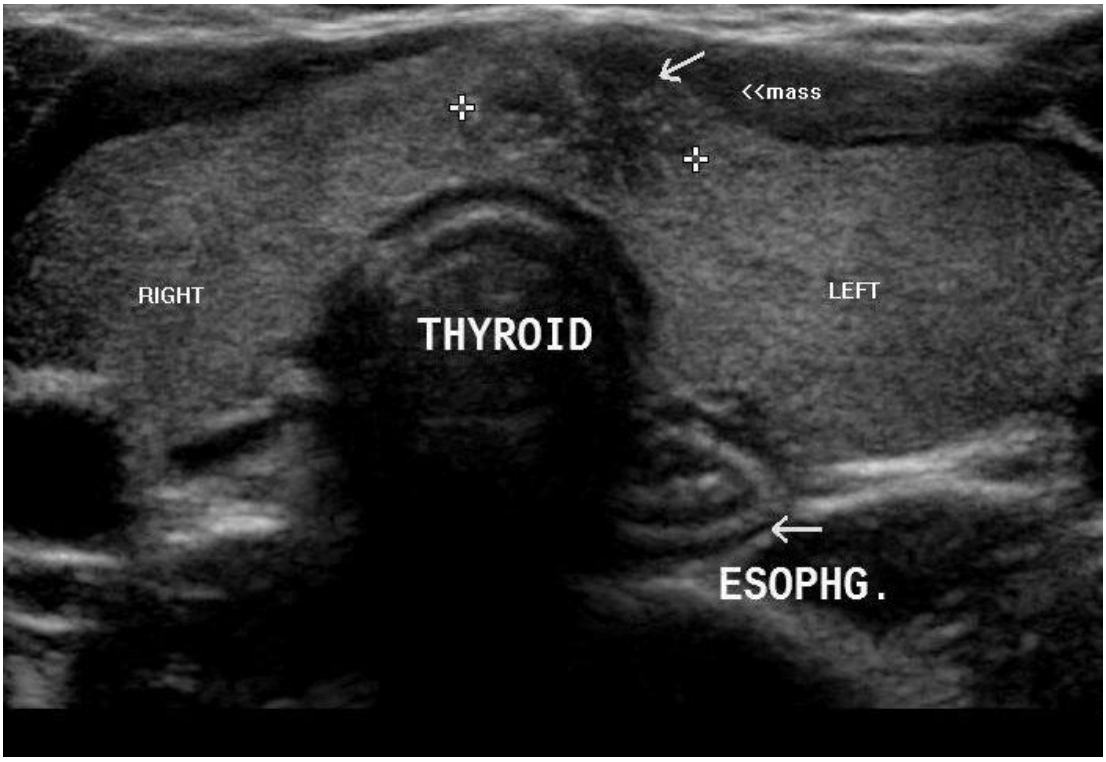
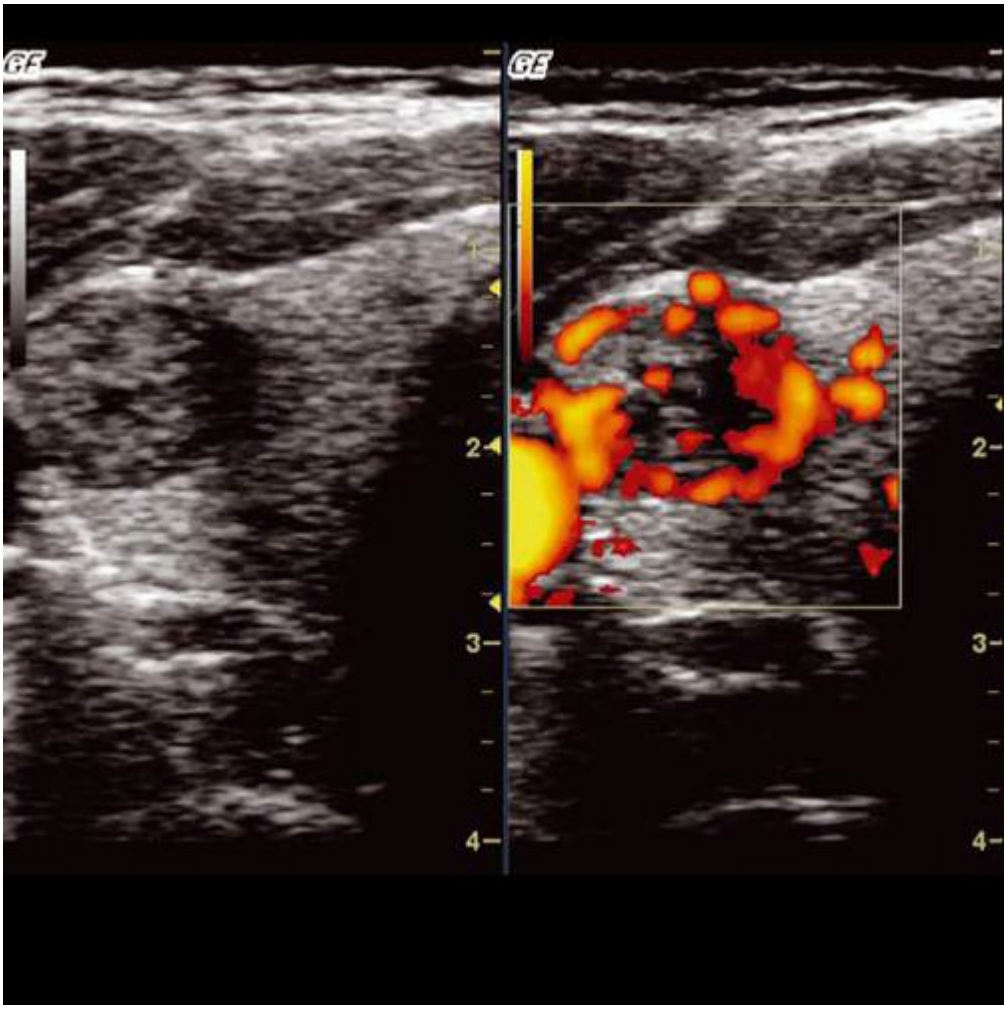


Figure showing hypo echoic
nodule as seen in ultrasound



Picture showing increased vascularity of thyroid nodule suggestive of malignancy in ultrasound

Radioisotope imaging:

This helps to ascertain whether a nodule is a functioning one or not. It does not provide an accurate estimate of the size of the nodule. Commonly used radioisotopes for this purpose include Technitium 99, I 123 and I 131. It has been estimated that about 90% of thyroid nodules are cold and non functioning. About 10% of these non functioning nodules show malignant transformation. The only use for this procedure is that it warns that the nodule is hot and functioning so that FNAC need not be performed on a hot nodule. Performing FNAC in hot nodules causes abnormally high increase of thyroxin in the blood causing thyrotoxicity which may have deleterious effects.

I 123 is more physiologic than technitium 99. Technitium 99 gets washed out of the gland and hence allows for shorter scanning time (20-30 minutes). Scanning can be immediately started after administering Technitium 99. If I123 is used then scanning can be started only after 24 hours after administration of the isotope. The scanning time lasts atleast 4 - 6 hours. Radiation exposure is more or less similar for both isotopes. Imaging resolution is better with Technitium 99 than radioiodine. Nodules below 1cm cannot be reliably detected by either of this scanning modality. Radioactive iodine scans can identify hot and cold nodules. The incidence of malignancy is more in cold nodule than hot nodule. Hot nodule is hyperfunctioning thyroid nodule, where as a cold nodule is a hypofunctioning nodule.

Indications for radioisotope imaging:

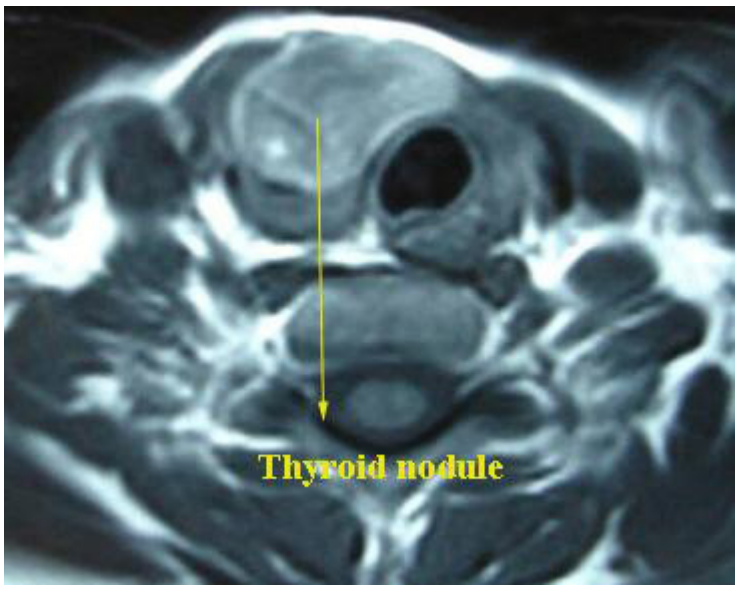
1. Identification of a functional solitary nodule when initial serum TSH is decreased.
2. If FNAC is reported as follicular neoplasm or suspicious lesion then the finding of Hot nodule in a scan may decrease the suspicion of malignancy
3. For detecting neck node metastasis.

Thallium 201 scan: is a very useful diagnostic tool to differential benign and malignant thyroid nodules. Three mCi of Thallium - 201 is used to image the thyroid gland. The uptake of the isotope is categorized into low uptake, intermediate uptake and high uptake. The risk of malignancy is more in high uptake lesions, and low in low uptake lesions.

Role of CT and MRI in thyroid nodule imaging:

CT scans are highly sensitive in detecting thyroid nodules. It is more useful to reveal mediastinal extension, retro tracheal extension and retroclavicular extension of the mass. Since the gland contains high iodine content, the brightness of the gland is increased on a CT even without contrast.

MRI plays a minor role in the evaluation of thyroid nodule. Its major advantage over CT scan is that contrast agent (gadoliunum) can be used without causing any interference to Radio nucleotide scanning.



CT scan neck sowing thyroid nodule

PET scan:

This scanning modality has been extensively used in diagnosing head and neck malignant lesions. Malignant cells show increased uptake of FDG because of increased metabolic demands due to cell division. This is of no use as far as thyroid nodules are concerned because there is no significant increase in FDG uptake between normal thyroid cells and malignant cells of thyroid gland. Normal values of FDG intake have no relevance, but patients with avid uptake of FDG then they need to be more thoroughly evaluated for thyroid malignancy.

FNAC:

Is the gold standard in evaluation of thyroid nodule. Since a majority of thyroid nodules are benign, this test is a must to identify the rarer malignant nodule.

Indications for FNAC:

1. Every patient with a thyroid nodule is a candidate for FNAC.
2. Before embarking on FNAC examination serum TSH estimation & ultrasound is a must
3. As a rule of thumb functioning nodules need not undergo FNAC because risk of malignancy is very low in them.
4. All cold / hypo functioning nodules as identified by radio nucleotide scan should undergo FNAC examination.
5. Nodules of any size which show positive features in ultrasound should undergo FNAC examination.

Procedure:

FNAC can be performed either by palpation / ultrasound guidance. If the nodule is palpable then it can be used as a guide as it would reduce the cost of investigation. The commonly available 22 / 27 gauge needles can be used to perform FNAC. Pathologists suggest using 25 / 27 gauge needles because samples harvested using them tend to be less bloody.
Various syringe holders have been advocated in order to enhance the suction effect produced. They include:

1. Cameco syringe pistol
2. Tao instrument
3. Inrad aspiration biopsy syringe / gun

It should also be borne in mind that the intrinsic suction effect provided by surface tension which these smaller diameter needles produce makes these fancy equipments redundant.
If FNAC is performed under ultrasound guidance then sampling should be done in different areas of the nodule including its wall, solid elements within and even calcified areas should not be ignored. Sampling should avoid cystic areas as yield from them invariably contains less cellular elements.
On insertion of the needle into the thyroid nodule a dwelling time of 2 – 5 seconds should be allowed. The needle should stay within the nodule during this dwelling interval. Then 3 forward and backward oscillations are performed in order to enhance the quality and quantity of yield. This maneuver also reduces blood contamination of the specimen.

Local anesthesia should be administered for all deep seated thyroid nodules. This will greatly reduce patient's discomfort and also enhance their active co operation.
For a thyroid FNAC to be reported as benign at least 6 groups of benign looking follicular cells should be present in a smear. Each of these groups should contain not less than 10 cells. It should also be stressed that any specimen containing abundant colloid should be considered benign even if the mandatory 6 groups of cells are not present in the smear. A sparsely cellular specimen with abundant colloid should always indicate a macro follicular node and hence certainly benign.

Two types of smears are prepared. Air dried and wet smears.
Dry smear: Two methods can be used. Diff - Quick method and May Grunwald - Giemsa methods. In quick dry method, the aspirate is expelled on to a glass slide, and is air dried. This method is best for immediate reading by the pathologist. The dried smear highlights the background colloid, cell architecture and cytoplasmic details. This technique is useful in the diagnosis of medullary and lymphoid tumors.

The wet smear (papanicolaou) is a wet smear that requires immediate fixation with 95% alcohol. This method is best suited for detecting papillary cancer.

FNAC will be reported as:
1. Unsatisfactory
2. Intermediate
3. Malignant
Intermediate group can be further subclassified into:

1. Follicular lesion of undetermined significance (FLUS)
2. Follicular neoplasm
3. Suspicious for malignancy as per Bathesda thyroid cytology classification
Ancillary procedures can be used to improve the accuracy of FNAC. These include:
1. Immunohistochemistry
2. Ploidy studies
3. Molecular markers
4. Reverse polymerase chain reaction
FNAC is the most important method in the diagnosis of malignant nodule. Other procedures that increases the accuracy of FNAC include studies of mutation involving BRAF, RAS, RET / PTC genes. Majority of papillary carcinomas will have mutations of the above mentioned genes. Mutations involving Ras proto oncogenes have been implicated in the pathogenesis of follicular carcinoma of thyroid gland.

It has been shown that sampling errors in FNAC increases as the size of the thyroid nodule increases. When the size of the nodule increases to 4 cms the false negative results also increase by 30%. Ultrasound guided FNAC can be performed if the nodules are small (1cm / less in size). It increases the accuracy of the procedure.

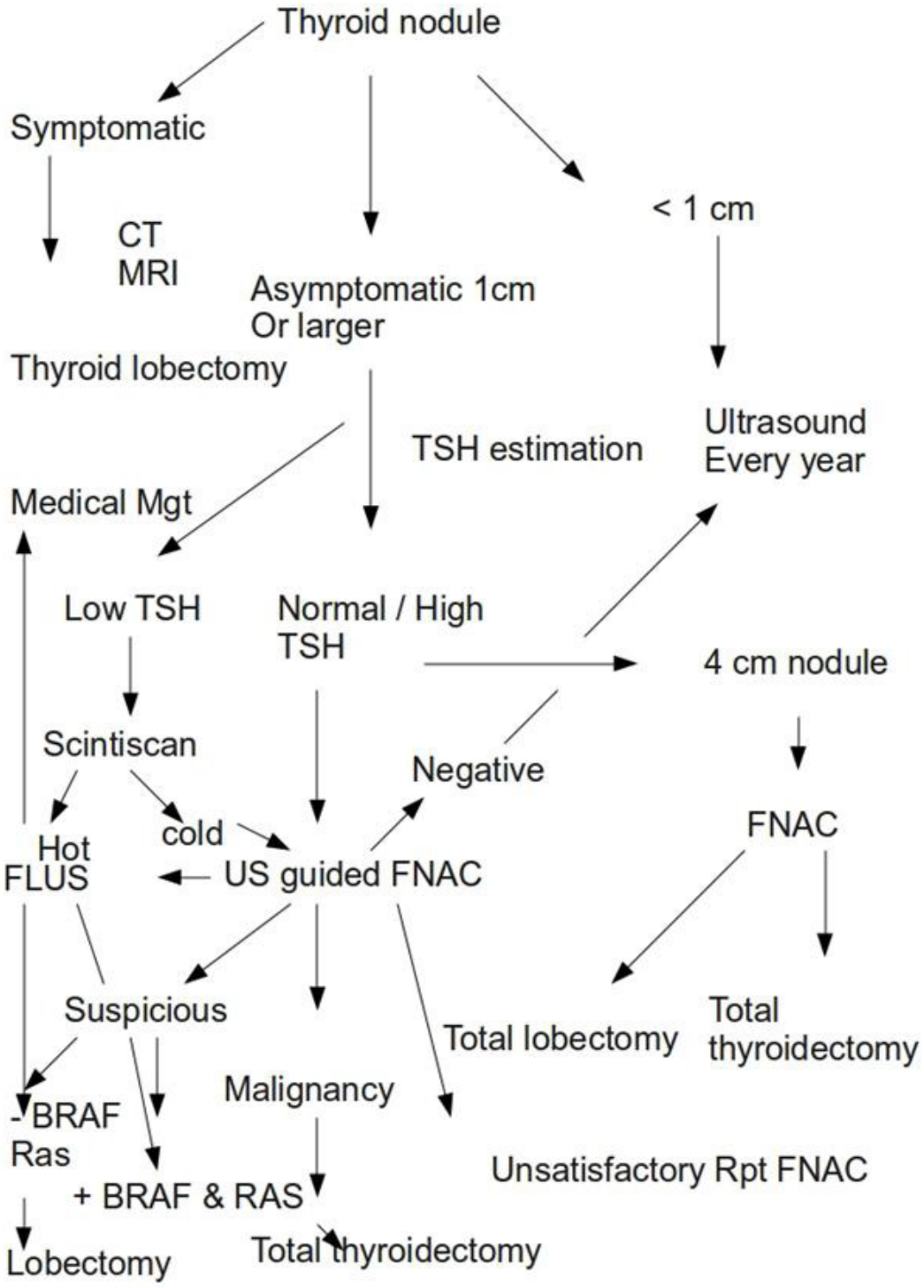
Frozen section analysis:
Thyroid tissue suspicious of malignancy can be subjected for frozen section analysis while the patient is still on the operation table. This will reduce the rate of patients who need to come back to the operation theater for completion thryoidectomy. The hemithyroidectomy specimen is sent for frozen section evaluation while the surgeon waits in the operation room. The report usually is expected within 15 mins. If it turns out to be mitotic lesion then total thyroidectomy is resorted to. If the report comes as benign lesion then the wound is closed and the patient is extubated.

American thyroid association guidelines regarding management of thyroid nodule:
American thyroid association has come out with detailed guidelines for managing patients with thyroid nodule. The salient feature of these guidelines is the incorporation of mutational analysis. These guidelines include:

1. All patients with asymptomatic thyroid nodule under 1 cm size should undergo
repeated ultrasound examination every year. FNAC is indicated in these patients only when there is a change in the growth pattern as evidenced by a rapid increase in the size of the nodule. Biopsy of nodules under 1 cm is indicated only when there is a history of radiation exposure or family history of thyroid malignancy.

2. Patients with asymptomatic thyroid nodule over 1 cm in size should undergo TSH estimation. Reduced TSH values in these patients should arouse suspicion of hot nodule (hyper functioning nodule). These patients should undergo thyroid uptake scan. Since patients with hot nodules have less than 1% risk of malignant transformation they are better managed medically by a medical endocrinologist.
3. If the nodule is asymptomatic and is 4 cm or more in size, FNAC should be done. This is because that these patients require surgery and a pre operative diagnosis of malignancy or otherwise will help in deciding whether the patient is going to undergo total thryoidectomy or hemithyroidectomy. If FNAC report turns out to be unsatisfactory then it should be repeated again. If FNAC is reported as follicular lesion of undetermined significance then it should be submitted for mutational studies. If FLUS (follicular lesion of undetermined significance) turns out to be positive for BRAF and RAS mutations then the patient should be submitted for total thryoidectomy. If mutational studies are not available then these patients should be offered diagnostic lobectomy. If FNAC reports the lesion as benign then these patients should be followed periodically by performing ultrasound examinations for any abnormal increase in size of the nodule. Attempts at suppressing the lesion by suppressing TSH levels are not effective. If FNAC report turns out to be malignancy then total thyroidectomy should be resorted to. Before embarking on total thyroidectomy ultrasound examination of neck should be performed to pick up any suspicious nodes which are too small to be palpated.
4. Patients with symptomatic thyroid nodules (symptoms caused due to obstruction) should be surgically managed. Symptoms could be airway obstruction or difficult in swallowing or change in voice. Change in voice occurs commonly in malignancy.

Figure showing thyroid nodule



Managment alogithm of thyroid nodule

Melkersson Rosenthal Syndrome

Introduction:

Melkersson – Rosenthal syndrome is a rare, non-caseating granulomatous disease which is characterised by a triad which includes facial paralysis, orofacial oedema and lingua plicata (scrotal tongue, fissured tongue, or furrowed tongue). It should be stressed that these triad of symptoms is not frequently seen in its complete form. The diagnosis of this condition is rather difficult because the classic triad of symptoms are seen only in 10% of patients with Melkersson – Rosenthal syndrome.

Etiology:

Etiology of this disease remains largely unknown however the following factors have been hypothetically implicated:

Infection
Genetic causes
Allergy
Benign lymphogranulomatosis

Histopathology:

Characteristic histopathologic features of this condition include:

Lymphoedema
Non caseating epitheloid cell granulomas
Presence of multinulceated Langhan's type giant cells
Presence of perivascular mononuclear inflammatory cell infiltration
Presence of perivascular fibrosis

Clinical features:

Patients with Melkersson Rosenthal syndrome may demonstrate the classic triad simultaneously or at different times. It should be stressed that in a patient with orofacial oedema the presence of one of the features given below is sufficient to make a diagnosis of Melkersson Rosenthal syndrome.

1. Idiopathic facial palsy
2. Lingua plicatica

Facial oedema:

This happens to be one of the dominant signs of Melkersson Rosenthal syndrome. The features of facial oedema in these patients include:

Acute oedema
Non pitting odema
Painless
Commonly affecting upper lip
Facial oedema may last from hours to weeks and may also recur

This facial oedema should be differentiated from angioneurotic oedema by its persistent nature, and non responsiveness to antihistamins and. Oedema is caused by fibrosis around blood vessels causing extravasation of fluid from them. The fibrosis also prevents reabsorption of extravasated fluid.

Facial paralysis:

In these patients facial paralysis may occur months to years before or after the onset of facial oedema. Facial palsy is commonly LMN type, unilateral / bilateral, partial or complete. 90% of these patients had recovery of facial nerve function.

Lingual Plicata:

Otherwise known as scrotal tongue / fissured tongue is commonly considered to be congenital developmental malformation.

Radiological evaluation which includes CT / MRI/Chest x-rays are non contributary in these patients. Histopathological features are the only available confirmatory diagnostic evaluation.

Other features associated with Melkersson Rosenthal syndrome:

Trigeminal neuralgia
Paresthesias
Ocular palsies
Blepharospasm
Epiphora
Keratitis
Psychotic episodes
Migraine

Treatment: Purely symptomatic.

Systemic / intralesional steroid therapy.

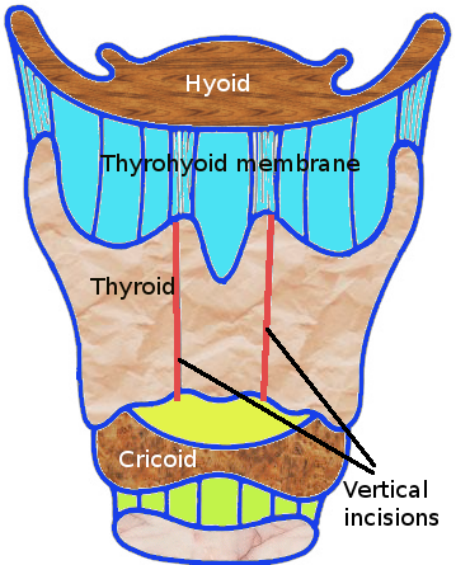
Drugs that have been tried with varying degrees of success include:

Sulfasalazine
Metronidazole
Clofazimine
Hydroxychloroquine

Surgical Management of Puberphonia
Recent Concepts

Introduction:

Mutational falsetto is also commonly known as Puberphonia. This condition is caused due to the failure of the voice to drop in its pitch from the higher levels after puberty. These patients hence suffer from lack of resonance in voice, breathiness of voice and lack of pitch variations. These patients have easy fatigability of voice and are unable to raise their voice in noisy environments.
This condition is caused due psychological problems in the patient which prevents lowering of the pitch of the voice of an adolesecent to that of a adult range. Puberphonia is more common in adolescent males and may also occur rarely in females.



The following are the probable psychological factors that could lead to the developement of puberphonia:

Over identification of the affected boy with his mother
Failure of the boy to accept his adult male role
Social immaturity
Anxiety to maintain a Soprano voice
Incordination of muscles of vocalization

The pitch of the voice in puberphonia is caused by increased tension of laryngeal musculature. This condition is responsive to voice therapy. If voice therapy fails then botulinum toxin injection into the cricothyroid muscle could be of help. Ideally 15 units of Botulinum toxin can be injected to each side.

Surgical management of Puberphonia:

When all the above conservative methods fail then surgery will have to be resorted to. Isshiki type III relaxation thyroplasty has shown promise in managing these patients. This surgical procedure lowered the pitch of voice in these patients by shortening the length of the vocal folds. In the classic Isshiki type III thyroplasty 2 – 3 mm of vertical strips of cartilage were excised on each side of midline of thyroid cartilage. This procedure caused retrusion of the middle portion of the thyroid cartilage causing a reduction in the length of the vocal folds.
Various modifications of Type III Ishikki thyroplasty have been proposed. These include:

Retrusion thyroplasty:

In this modified procedure the lamina of thyroid cartilage is incised bilaterally and its anterior segment is depressed anteriorly.

Relaxation thyroplasty:

In this procedure a small window is created close to the anterior commissure tendon and the cartilage window created is pushed behind.

Tucker's procedure:

This is a less invasive procedure in which a superiorly based cartilage window is created at the level of anterior commissure and is pushed behind causing relaxation of the vocal folds.

This surgical procedure is very useful in treating patients in whom psychologic counselling and voice therapy has failed.

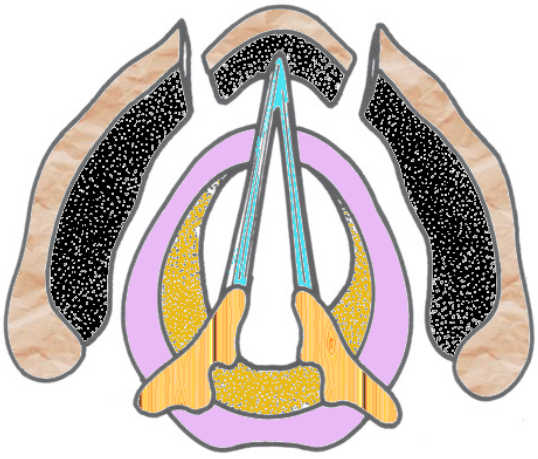


Figure showing the depressed anterior segment of the thyroid cartilage

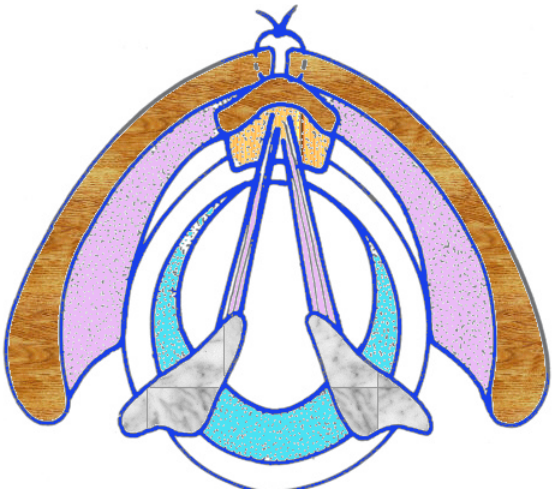


Figure showing anterior segment of thyroid cartilage being pushed behind and the edges of cartilage sutured

Anatomical changes that occur in ethmoid sinuses following FESS

Introduction:

The bony walls of paranasal sinuses demonstrate excellent degree of plasticity. This feature allows alterations in the size and dimensions of paranasal sinuses during growth phase. The process of pneumatization of paranasal sinuses begins in utero and continues through teenage years.
Causes of pathological expansile alterations of paranasal sinuses include:

Allergic fungal sinusitis
Extensive sinonasal polyposis
Mucocele formation
Benign tumors

Pathological causes of contractile changes in sinus cavity:

Cystic fibrosis
Silent sinus syndrome – caused due to obstruction of sinus ostium leading on to atelectasis of maxillary sinuses.

While performing endoscopic sinus surgery it should be borne in mind that it is being performed in a setting of bony changes, with an intention to halt the expansile / contractile changes that are likely to take place.

While performing endoscopic sinus surgery in paediatric age group it should always be borne in mind that there is a real time risk in causing irreversible bony changes in a growing bone causing undesired changes in the facial morphology. Recent studies however counter this claim saying that it is very safe to perform ESS in peadiatric age group.

Anatomical changes that take place in the ethmoidal sinuses of adult patients who have undergone ESS:

This is a largely understudied topic. Few studies that have been performed by analysing the axial CT scans pre op and post op has demonstrated that there is bowing of lamina papyracea following surgery. This medial bowing caused a reduction in the volume of ethmoidal sinuses by 1mm cube. The amount of bowing was proportional to the extent of surgery. Maximum changes in the ethmoid sinus dimensions occured at the level of posterior globe.

Michel Platt etal in their work have suggested that a total of 5 measurements should be made before coming to a conclusion that there is a definite change in the dimensions of ethmoidal sinuses. These measurements should be made in the pre op and post op CT scans of the patients.

The distance between both lamina papyracea were measured in the axial plane at the level of planum sphenoidale.
The distance between both lamina papyracea are measured in the axial plane at the mid globe level.
The distance between both lamina papyracea are measured in the axial plane at the posterior globe level
The distance between both lamina papyracea are measured at the level of anterior wall of sphenoid sinus

In the coronal plane the authors advised measurements to be made consistently at the:

Plane of posterior globes
Level of cribriform plate
At the length of 5-10 mm below the cribriform plate

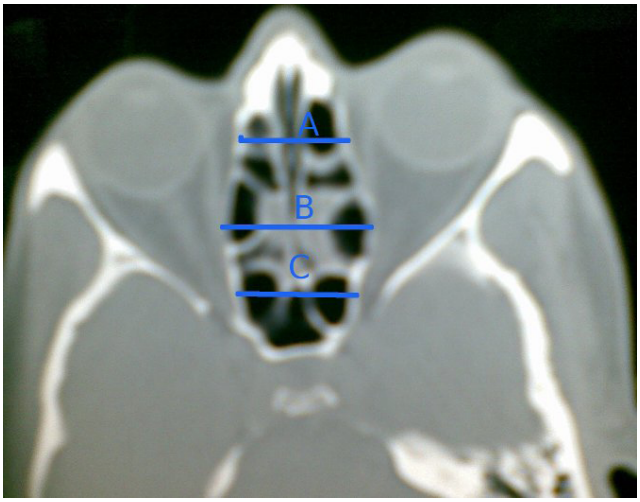


Figure showing the three areas from where measurements are taken in axial cuts

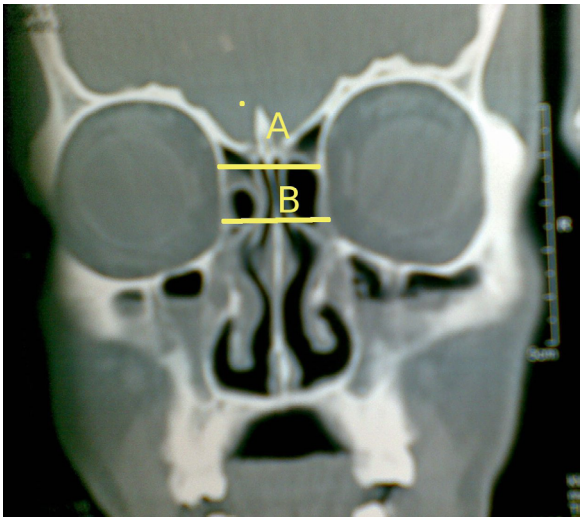


Figure showing the areas from where measurments are taken in coronal cuts

Role of Microdebriders in Otolaryngological surgery

Introduction:

Microdebriders should be considered to be next only to an endoscope in rhinological surgical procedures. It is hence considered to be the most important innovations in the field of rhinology and endoscopic sinus surgery. In recent times this instrument is becoming really popular thereby reducing the reliance on traditional non powered sinus instruments like currettes and forceps.

Advantages of microdebriders include:

1. It spares the adjacent mucosa (Mucosal sparing)
2. It is precise
3. Removes tissue real fast
4. Visualization is really good
5. Since the blade comes in different angles it can be used to cut tissues from even inaccessible areas inside the nose
6. The suction applied to the blade sucks and holds the tissue for better cutting effect

History:

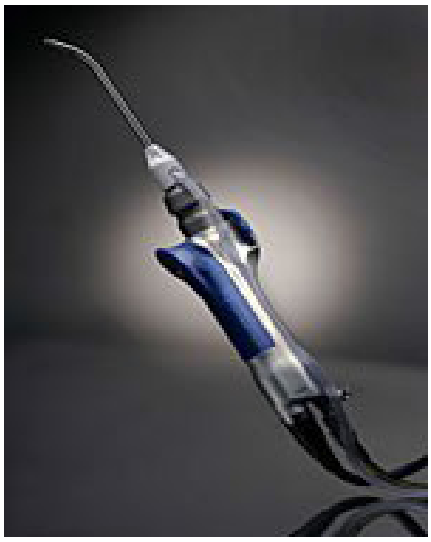
Originally the concept and design of microdebrider was patented by Urban in 1969. In his patent application he called the equipment "Vacuum rotatory dissector". This equipment was originally used by the House group to remove acoustic neuroma during 1970's. Orthopedic surgeons started using it for arthroscopic surgeries from the year 1975.
It was only from the year 1994 Setliff and Parsons started using this equipment for nasal surgeries. Improvements to this original vacuum dissector started taking place by leaps and bounds.

The originally patented Vaccum dissector was cylinderical, electrically powered shaver system which is supplied with continuous suction. The basic design which was patented has a hollow shaft with a rotating / oscillating inner cannula.
The suction applied draws the soft tissue inwards and is trapped there. This trapped tissue is sheared off by the rotating blade between the inner and outer cannulas.

The slower the rotating speed of the blade larger is the tissue bite, at higher speed rates the instrument becomes less aggressive. The sheared bits of tissue is sucked by the suction effect. Irrigation via a side portal is performed in a continous basis. Irrigation helps in preventing the bits of tissue from blocking the suction portal of the hand piece. The bits of tissue sheared by debrider blade can be collected and sent for histopathological examination also.

Hand piece design:

All the commonly used debrider handpieces still maintain the cylinderical design of the original patent of Urban. The cylinderical design permits the surgeon to hold the hand piece as if it were a scalpel.



Images showing microdebrider hand piece and the way it should be gripped

The Diego microdebrider provides a pistol grip handpiece. Some surgeons find this comfortable.

With the image guidance systems becoming common handpiece manufacturers have made handpieces that can be easily coupled with image guidance system.

Debrider blades:
These blades are disposable. They come in various configurations. Their edges can be straight or serrated. Straight edged blades are less traumatic and has more tissue sparing effect, whereas serrated ones allow for better gripping of tissue. It has an inner and outer cannula. The inner cannula's edge happens to be the blade. The outer cannula serves as a conduit for suction, irrigation and the inner cannula.

Depending on the relative angles of the inner and outer cannulas the cutting action of the debrider blade could either be gulliotine or scissors. Most of the debrider blades has a scissors like cutting action with an angle between the openings of the inner and outer cannulas hence the shearing force is applied only to a small tissue area at a given time. In debrider blades with a guillotine cutting mechanism the apertures of the two cannulas run parallel to one another hence it shears off the entire bit of tissue.

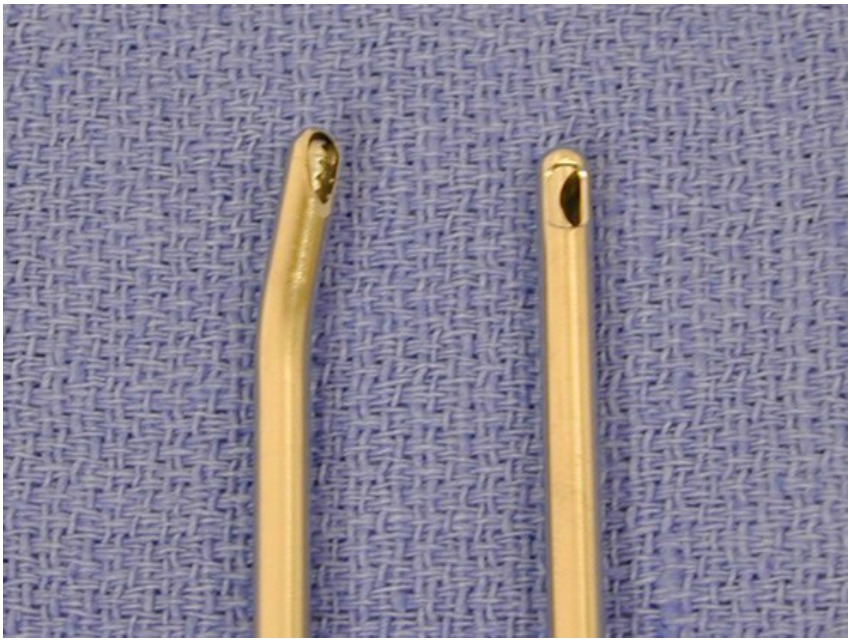


Figure showing the two basic types of debrider blades

These blades can either be set to osscilate or rotate. Oscillation usually runs at a slow speed (5000 rpm) and is useful for soft tissue resection. At slower speeds the port remains open longer allowing more soft tissue to be drawn into the aperture before the cut could be made. This adds to the efficiency of soft tissue resection.

Forward and reverse rotations are faster (upto 15,000 rpm) and more or less has a drill like action and hence could be used to drill bony structures as in endoscopic dcr, reduction of bony septal spur etc. Since the speed is too low for drilling bony structures when compared to the mastoid microdrills, it takes a long time to drill bony structures using a microdebrider. Recent innovations in microdebrider blades is the availability of blades which are prebent to suit the various angulations of resection inside the nasal cavity.

Image showing prebent blades

Special microdebrider blades:
These blades are made to perform specific tasks.
Tonsillectomy blades:
These blades are used to perform extracapsular tonsillectomy. These blades are wider with low angles to enable it to function as a guillotine. These blades usually come in 4mm diameters.
Adenoidectomy blades:
These blades are curved and hence can be introduced through the nasal cavities. The curvature of these blades mimics the curvature of the nasal cavity.

Adenoid curved blade

Tonsil blade

Turbinectomy blades:
These blades are used to perform inferior turbinectomy. These blades are small diameter blades (2-2.8 mm). It has a bevelled guard at the back which protects the turbinate mucosa while the vascular erectile tissue is being dissected. This mucosal protection causes lower incidence of osteitis of the inferior concha.

Role of debriders in clearing up the operating field:
Clearing the operating field of blood and other secretions is a must for better visibility during nasal endoscopic sinus surgery. Even small amounts of bleeding can significantly impair visibility during endoscopic surgeries. Debriders have the ability to continuously suck blood and dissected tissues out of the surgical field is a great advantage.
Recent modifications in debrider technology have managed to add the ability to cauterize bleeders using bipolar cautery delivered via the end of the blade. These blades themselves are surrouned by layers of insulation causing a sandwiching of the inner and outer electrodes. These instruments can be set to cauterize bleeders in three settings:
1. Low – 10 Watts
2. Medium – 20 Watts
3. High – 40 Watts
The only drawback of these blades is that only a small zone of bipolar cautery is present.

Microdebrider drills:
Eventhough microdebriders are not suited for drilling bone, the thin ethmoidal bones can easily be drilled using drill bits in place of debrider blades. These drill bits are commonly used in endoscopic dacryocystorhinostomy procedures. These drill bits are diamond drill bits (2.5 mm) size. The number of grooves in the drill bit determines the speed of drilling.
Fewer grooves result in faster and aggressive drilling of bone. This always comes with a price (poor control).
As the number of grooves in the drill bits increases, the bone take down rate slows down but the control is much better. Diamond burrs cause less aggresive drilling than normal burrs.

Where do you use microdebrider drill bits:

1. In Endoscopic DCR
2. In frontal sinus surgeries
3. In trans sphenoid pituitary surgeries
4. In Endoscopic skull base surgeries

Limitations of microdebriders:

1. Slow rotation rates – Debriders rotate at slow rates (15,000 rpm) as compared to that of microdrills (80,000 rpm) thus making it inefficient to drill bony structures.
2. Tactile feedback is less while operating with microdebriders when compared to that of conventional instruments
3. It should be used carefully in confined spaces close to vital structures in order to avoid damage to them
4. Initial cost of equipment and recurring expenses incurred towards purchase of blades increase the cost of surgery.

Various components of microdebrider:
A debrider contains three components.
1. The console which helps in controlling the speed of rotation/direction of rotation. These parameters can easily be changed with the help of a attached foot pedal.
2. The blade: This is a tubular metal structure with serrated edge / smooth edge. The cutting edge is present only on one side only, while the smooth opposite surface does not cut. It is usually connected to a suction tube. These blades come in various sizes and configurations. This blade allows for simultaneous cutting and removal of cut tissue by suction.
3. Handpiece: Which is a portable micromotor. It derives its power supply from the console. The blade is attached to the shaft of the hand piece.

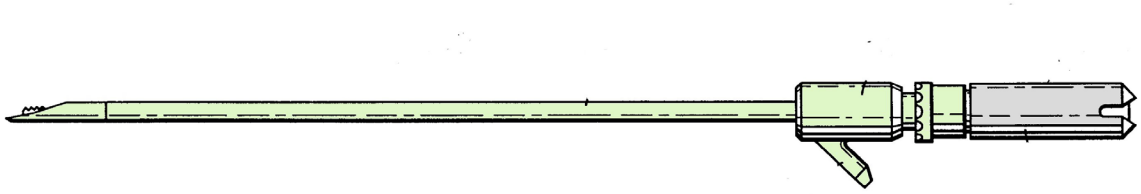


Figure showing turbinectomy blade

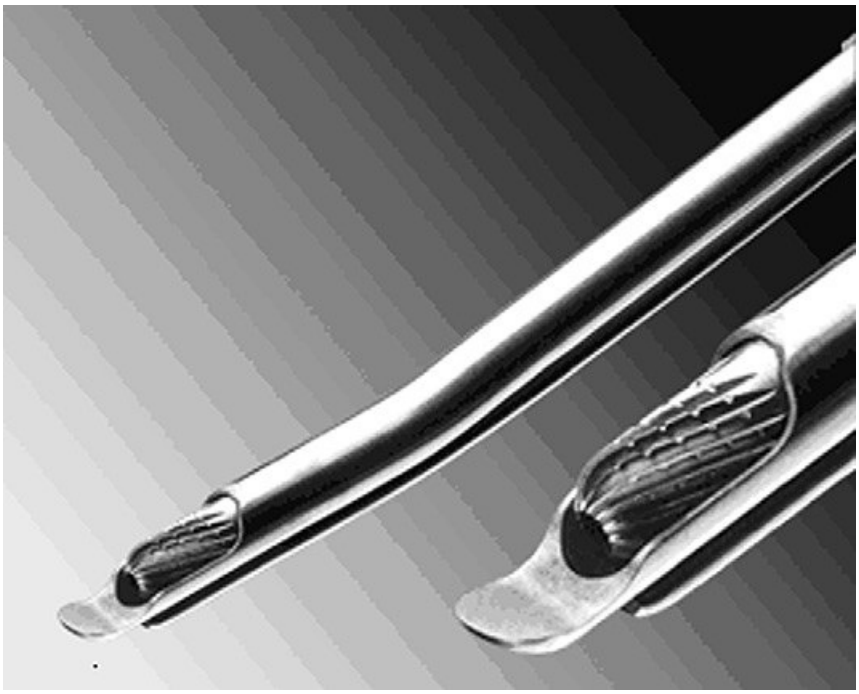


Image showing sheathed debrider drill bits

Image showing debrider console

Nasal topical therapeutics

Introduction:

Intranasal drug delivery systems for the management of local and systemic ailments have caught up recently. Initially this route of drug administration was attempted for the management of allergic rhinosinusitis. Now inflammatory sinusitis is also managed by intranasally administered drugs. The reasons for interest in this route of drug administration because of its high vascularity, porous endothelial basement membrane and a high total blood flow per volume of tissue.

Since first pass metabolism is avoided in this drug delivery method the drug is metabolized slowly thus helping in reducing the dosage of the drug. This also goes a long way in reducing the potential toxicity of the administered drug even if it has a very low therapeutic index.

The complex nasal anatomy and the varying dynamics of nasal air flow make this drug delivery modality a little bit unpredictable. This is more so especially in patients with nasal cold which is associated with congestion of nasal mucosa and turbinates.

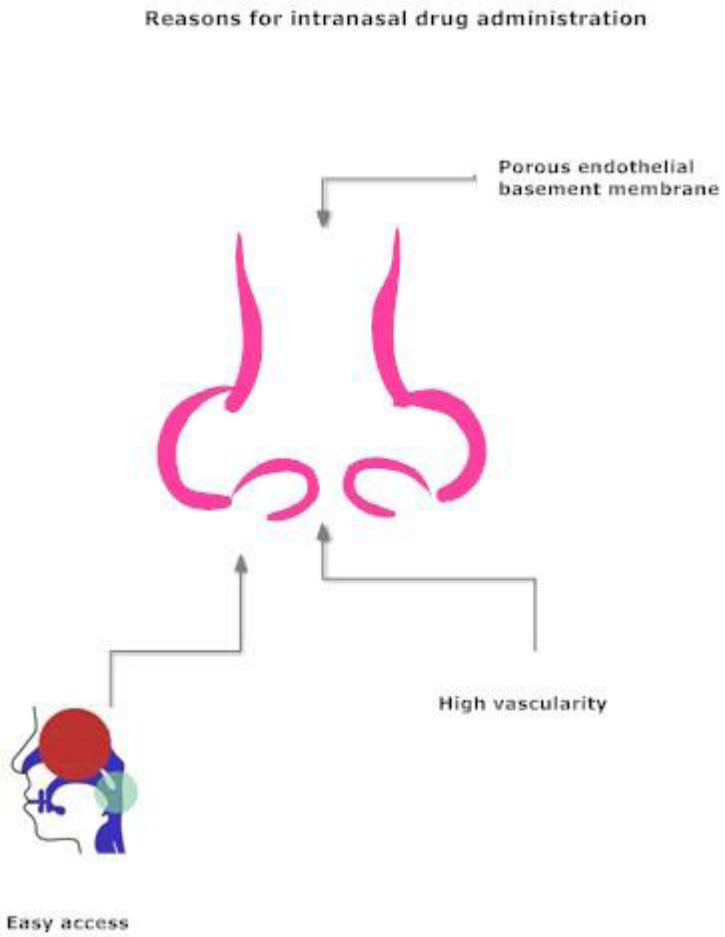


Figure showing reasons of intranasal drug administration

Variables that have a significant bearing on intranasal drug absorption:

1. Particle size of the drug
2. Flow volume
3. Pressure
4. Spray angle
5. Complex anatomy
6. Nasal airflow dynamics

Role of particle size of the drug:

Primary nasal drug delivery system works on the inertial impaction while the drug is deposited and secondarily gravitational sedimentation and Brownian diffusion play their roles. Hence the particle size and its density affect the degree and site of deposition. Drug particles greater than 10 μm tends to remain inside the nasal vault while drug particles with size less than 5 μm remain aerosolised and get absorbed from the lower airway. Experiments have shown that by reducing the size of the molecule and by increasing the flow rate of the drug administered the efficacy of intranasally administered drug can be improved.

Significant amount of intranasally administered drug gets deposited in the anterior nares to be cleared during the next expiratory effort thus reducing the efficacy of the drug administered.

Physiologic obstacles that prevent optimal absorption of intranasally administered drugs:

Mucous barrier and mucociliary clearance mechanism:
The nasal cavity can be divided into:

1. Vestibule (about 0.5 – 1 cm2) – is lined by stratified squamous epithelium. This epithelium is highly resistant to dehydration and penetration by noxious chemicals. It also is also poorly permeable to nasally administered drugs.
2. Respiratory epithelium (about 130 – 150 cm2) – covers the maximum surface area of the nasal cavity. It is lined by pseudostratified columnar epithelium with cilia, goblet cells, basal cells and seromucinous glands. The cilia present over the columnar epithelium serves to increase the absorptive surface area more.
3. Olfactory epithelium (20 – 50 cm2).

Following deposition into the nasal cavity the mucous blanket is the first obstacle encountered by the drug administered. This mucous blanket is roughly 5 μm thick. Each day about 1.5 – 2 litres of mucous is secreted. This mucous blanket not only increases the thickness the drug needs to penetrate to reach the blood stream, it also washes out the drug. For optimal absorption of the drug this mucosal barrier should be penetrated. Several strategies have been developed to enable a drug to breach this mucosal barrier.

These include:

1. Lipid solubility of the drug. If the drug is lipid soluble then it breaches the mucosal barrier easily.
2. Smaller molecules penetrate mucosal barrier better than larger ones.
3. Combining the active drug with a mucolytic like N – acetyl cysteine or Dornase alpha increases the chances of the drug penetrating the nasal mucosa.

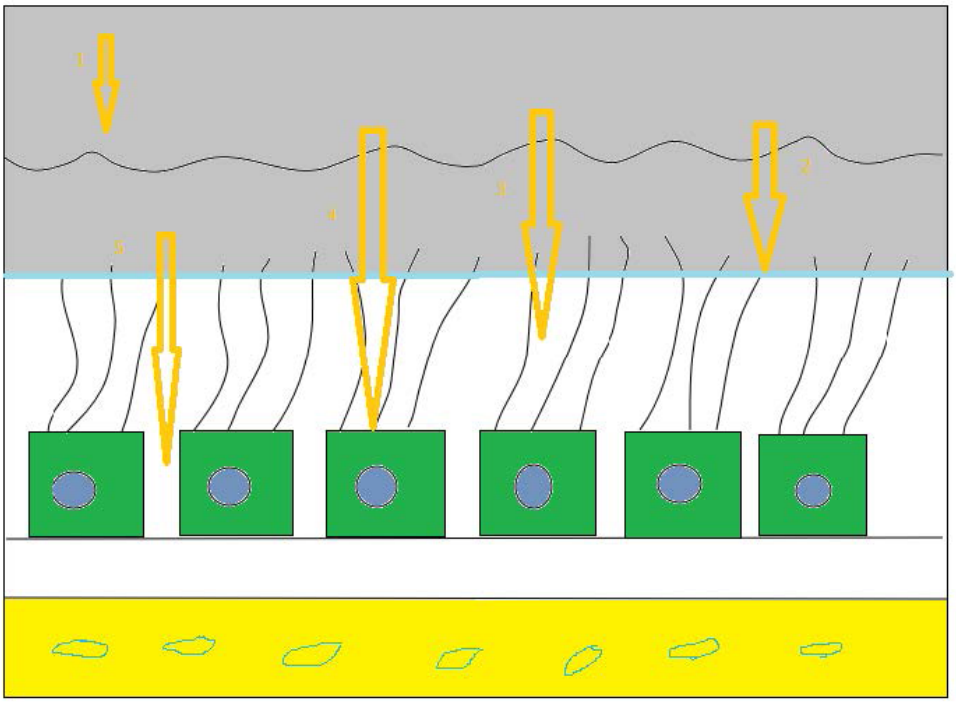


Figure showing various physiological barriers for intranasal drug absorption.

1. Deposition of the drug
2. Distribution to the mucosal surface
3. Ciliary beat clearing the drug
4. Cellular lipid bilayer (barrier to water soluble molecules)
5. Intercellular skeleton constituting the intracellular barrier

The mucous blanket which plays a vital role in drug clearance does its job virtually in 20 minutes flat. This mucous blanket can be circumvented by using bio adhesive drug carriers which would stick to this mucous barrier there by prolonging the exposure of mucosa to the drug administered.

Enzymes present in the mucous secretions:
Various degrading enzymes have been identified in the mucous blanket of nasal mucosa. These enzymes act on the drugs deposited in the nasal mucosa and degrades them by any of the following chemical reactions:

1. Hydrolysis
2. Oxidation
3. Isomerization
4. Photochemical decomposition
5. Polymerization

The effect of enzymes can be countered by simultaneous administration or co administration of protease inhibitors like bestatin or L-aspertase.

Epithelial permeability:

After successfully traversing the mucosal blanket, the drug must then be absorbed through the intact epithelial surface. The epithelial barrier is composed of two components i.e. cell wall and intercellular tight junctions.

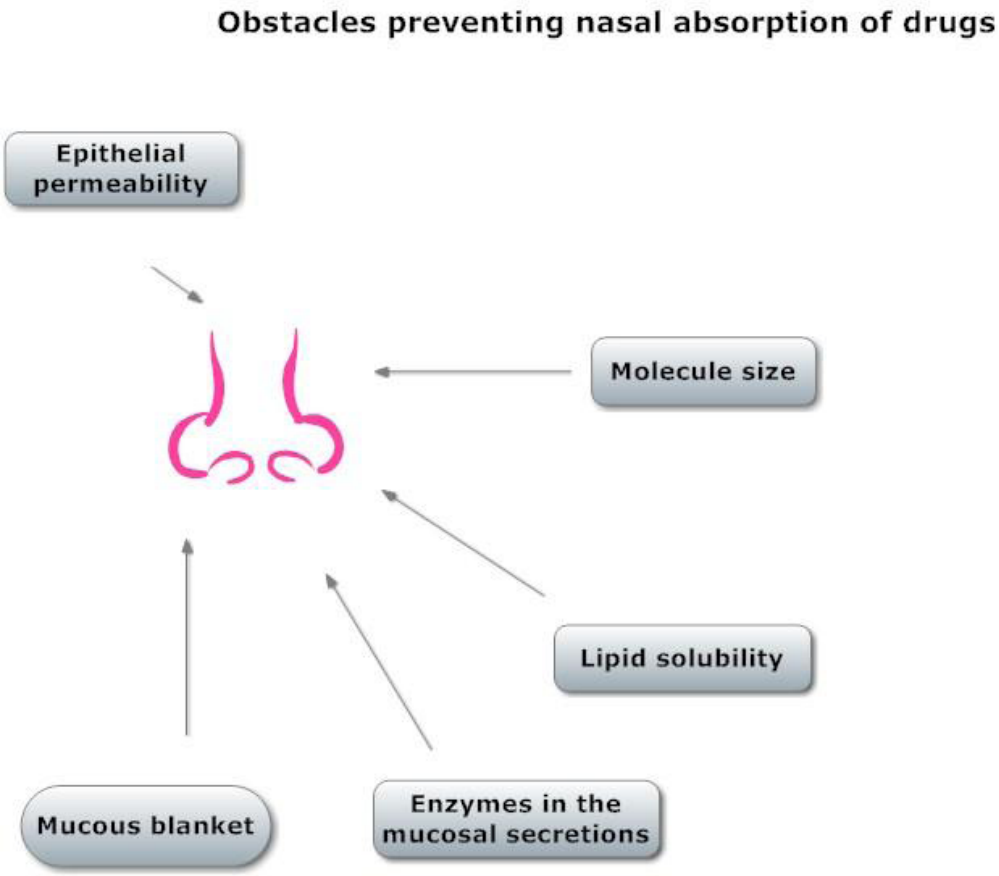
Cell wall: Is composed of phospholipid bilayered wall which favours penetration by lipophilic low molecular weight molecules (less than 1000 Da). Hence if the drug is lipophilic and of low molecular weight then it will easily penetrate this barrier.

Tight junctions: Binds the cells together. These junctions are responsible for dynamic regulation of paracellular transport of substances. These junctions are composed of membrane proteins that connect directly to the actin cytoskeleton. Claudins represent a major component of tight junctions.

In order to by-pass these inherent obstacles the drug administered into the nasal cavity as prodrugs. This drug is inactive till it gets absorbed through the cell wall and gets metabolized into its active component by the enzymes present in the system i.e. either in blood or liver. Example of such prodrug is testosterone 17b-N, N-dimethylglycinate hydrochloride.

The second strategy to deliver optimal doses of drug through nasal mucous membrane is to increase the permeability of the lipid bilayered cell wall by using permeability enhancers like sodium glycocholate, sodium lauryl sulphate. Drugs combined with these permeability enhancers will easily penetrate the cell wall. These enhancers should be used with caution as they can cause irreparable damage to the cell wall if used in high concentrations. These enhancers belong to the amphipathic group of molecules which are capable of dissolving both in water and lipid. Chemicals belonging to this group have been classified as:

1. Cationic
2. Anionic
3. Zwitterionic – possessing both anionic and cationic components



Johnson and Johnson baby shampoo can be used in 1% concentration to serve this very purpose of breaching the nasal mucosal barrier.

The third strategy to deliver optimal doses of drug through nasal mucosa is to make use of the tight junction transport system. This method focuses on enhanced drug delivery system rather than causing any changes in the cellular layers. The poor water solubility of lipophilic drugs results in suboptimal drug absorption. If the drugs are dissolved in cyclodextrins which act as aqueous vehicle for the drug then its penetration via tight junctions is improved.

Development of mucoadhesive drug eluting polymers:

In order to overcome the challenges confronting nasal route of drug administration a new frontier in drug dispersion has been thrown up. It is known as biocompatible drug eluting polymer. These polymers can be theoretically loaded with the pharmaceutical agent and implanted in any location. The active agent will be released into the circulation periodically from these polymers which adhere to the nasal mucosa. One such polymer is the Chitosan. The advantages of this polymer are multifold:

1. It has excellent mucoadherent property
2. It is a hemostatic agent
3. It has antimicrobial properties
4. It is a viable tool in transferring adequate quantities of steroids into the nasal mucosa

Nano particulate drug carriers:

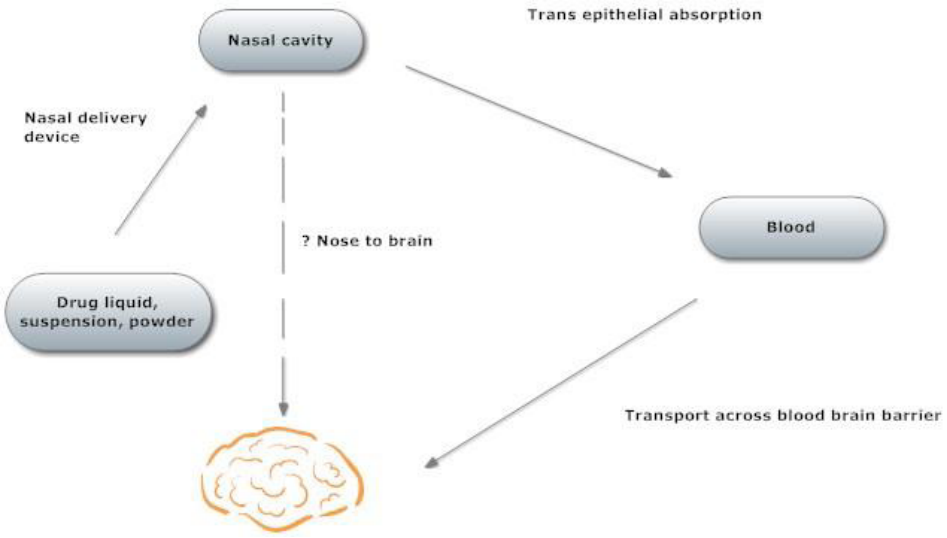
This is an alternative approach to enhance the drug delivery into the nasal cavity. This method involves complexing pharmacologically active agents to particulate carriers capable of selectively binding to cell surface proteins or mucous blanket. These carriers can be manufactured in sizes as small as 200 Nano meters. This small size allows the drug to readily diffuse into the cell of nasal mucosa. These nano particles enter the nasal mucosal cell by an active process known as endocytosis.

Advantages of nasal drug delivery system include:

1. Large mucosal surface area making efficient drug absorption possible
2. Porous endothelium facilitates better drug absorption
3. High total blood flow enabling efficient transportation of the absorbed drug
4. Decreased enzymatic degradation
5. Avoidance of first pass metabolism
6. Non invasive
7. Painless
8. Does not require sterile preparation
9. Improved delivery route for non-Lipinski group of drugs
10. Nasally administered drugs have been shown to reach brain in adequate concentrations

Use of topical agents in the management of chronic sinusitis:
Two factors must be borne in mind while using topical agents in managing chronic sinusitis i.e. mechanical lavage and pharmaceutical intervention. These two factors are potentially conflicting and hence an optimal balance must be struck whenever topical application of drug is desired in managing rhinosinusitis.

Role of mechanical lavage: Lavage facilitates mechanical removal of mucous, antigen, pollutants, inflammatory products, bacteria, bacterial products and biofilms. Lavage should be performed using high volume positive pressure irrigation of the nasal cavity in order to provide the necessary shearing force for clearing these substances. Administration of drugs into the nasal cavity cannot be done using the high volume positive pressure route because prolonged mucosal contact time is necessary for optimal absorption of the drug from nasal cavity.



Delivery devices:
Nebulizers – Drugs delivered using nebulizers does not adequately penetrate the sinus cavity.
Large volume squeeze bottles – This group of device is very useful in administering drugs after endoscopic sinus surgery.

Netipots – Drug administration using Netipots can be used in non-operated sinuses because of the head position and retrograde flow which facilitates better drug permeation into the nasal cavity.
Simple low volume sprays and drops – Distribution of drugs when low volume sprays and drops is highly erratic and suboptimal and hence should be used for nasal cavity treatment only.

Figure showing a Netipot

Enhancement of drug delivery sans mucosal blanket: The presence of mucous blanket significantly affects intranasal drug delivery. Removal of this mucosal blanket will augment intranasal drug delivery. This mucous blanket is excessive in patients with rhinitis. Irrigation of nasal cavity with hypertonic saline before administration of nasal steroids enhances its absorption.

Drugs that can be administered through the nose:

1. Steroids
2. Insulin
3. Vasopressin
4. Oxytocin

Intranasal topical steroids: are commonly used to treat patients with seasonal allergic rhinitis, perennial allergic rhinitis and non-allergic rhinitis. It has been demonstrated that fluticasone propionate resides in the nasal mucosa for 24 hours. While applying intranasal steroid spray the nozzle of the bottle should be directed towards the lateral nasal wall. This ensures that the drug reaches the portion of the nose which is maximally affected by allergic reaction. The nasal cavity should be cleared of mucous before spraying the nasal cavity with the drug.

Vaccine delivery through nose: The ability of nose associated lymphoid tissue to generate cell mediated as well as humoral immunity has kindled interest in using this route for vaccine administration. This route will be very useful in undertaking mass immunization programmes. One classic example of vaccine which can be administered through nose is Flumist (live influenza virus vaccine). Vaccine administered through the nose should contain antigen coupled with a mucosal adjuvant or carrier. Advantages of using this route for immunization include:
1. It is painless
2. The vaccine administered need not be sterile
3. Since nose happens to be a potential portal of entry for infections this route can increase local immunity

Intranasal morphine for management of intractable cancer pain:
Morphine administered orally has very poor bioavailability due to extensive first pass metabolism hence intranasal route is preferred. Morphine administered via nose is rapidly absorbed, avoids first pass metabolism and is non-invasive.
Intranasal acetyl cholinesterase inhibitors in treating Alzheimer's disease: Galantamine an acetyl cholinesterase inhibitor has been administered with reasonable degree of success in managing patients with Alzheimer's disease.

Antinausea and motion sickness medications: Treatment of nausea and motion sickness is ideally performed using intranasal route of administration. Intranasal metoclopramide has been used intranasally with reasonable degree of success in managing post-operative nausea. Scopolamine an antimuscarininc drug used for managing motion sickness is another drug that can ideally be administered through the nose.

Avoiding pitfalls in Endoscopic skull base surgery

Introduction:

The advantages of endoscopic approach to skull base are many. They include:

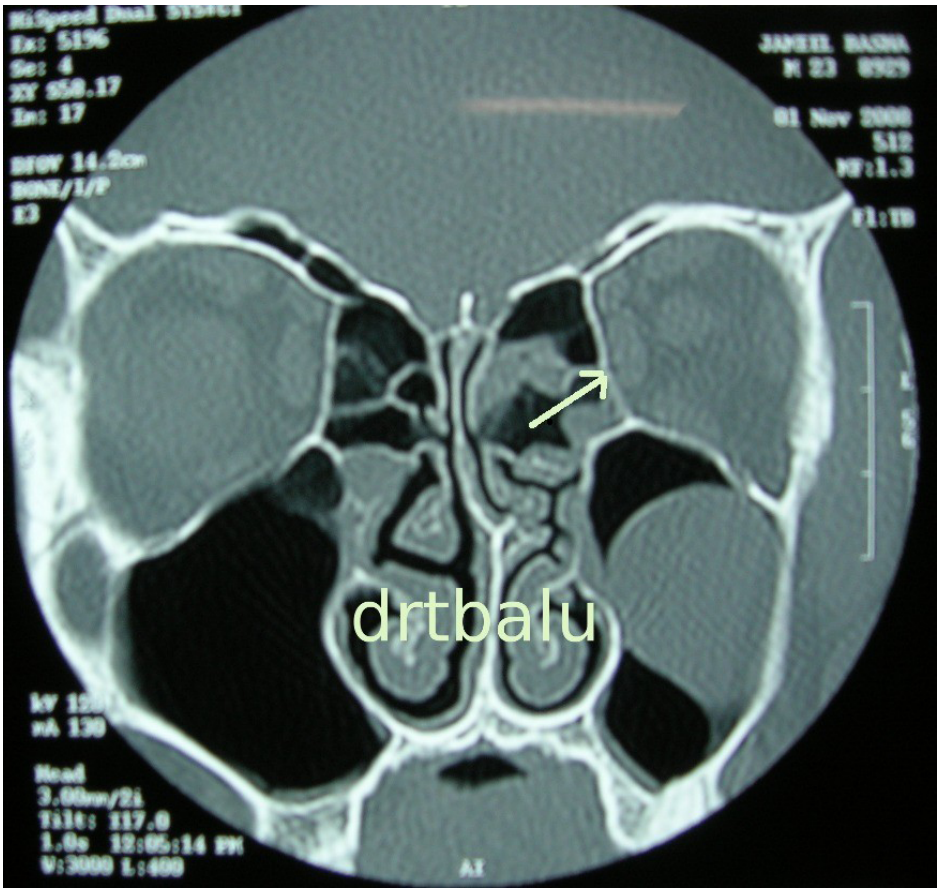
1. It is the most direct route to anterior skull base. This approach provides access to the following areas Sella, Cribriform plate, Planum sphenoidale, suprasellar cistern, Clivus, Pterygopalatine fossa and adjacent parasellar areas.
2. In this approach there is decreased retraction of brain and cranial nerves when compared to that of conventional neurosurgical apporaches.
3. Endoscope offers excellent visualization of the tumor and the surrounding neurovascular structures
4. Post operative recovery time is short when compared to that of conventional neurosurgical approaches

As with any other procedure this method also has its flip side, which includes a steep learning curve, and need to collaborate with neurosurgeon. A cohesive collaboration with neurosurgeon is a must for successful endoscopic skull base surgical procedures.The complicated anatomy of skull base has managed to bridge these two specialities. In a nut shell an otolaryngologist navigates the pathway to the intracranial lesion while the neurosurgeon removes the tumor.

Dangers of endoscopic skull base surgery:
Since the skull base has many vital structures it should be performed with the highest degree of deligence and skill. The potential complications of any endoscopic skull base surgery include:
1. CSF rhinorrhoea
2. Injury to great vessels (internal carotid artery and its branches inside the skull)
3. Injury to optic nerve
4. Injury to other cranial nerves
5. Bleeding from cavernous sinus
6. Meningitis
Steps taken to prevent these complications include:

CT MRI scan review:

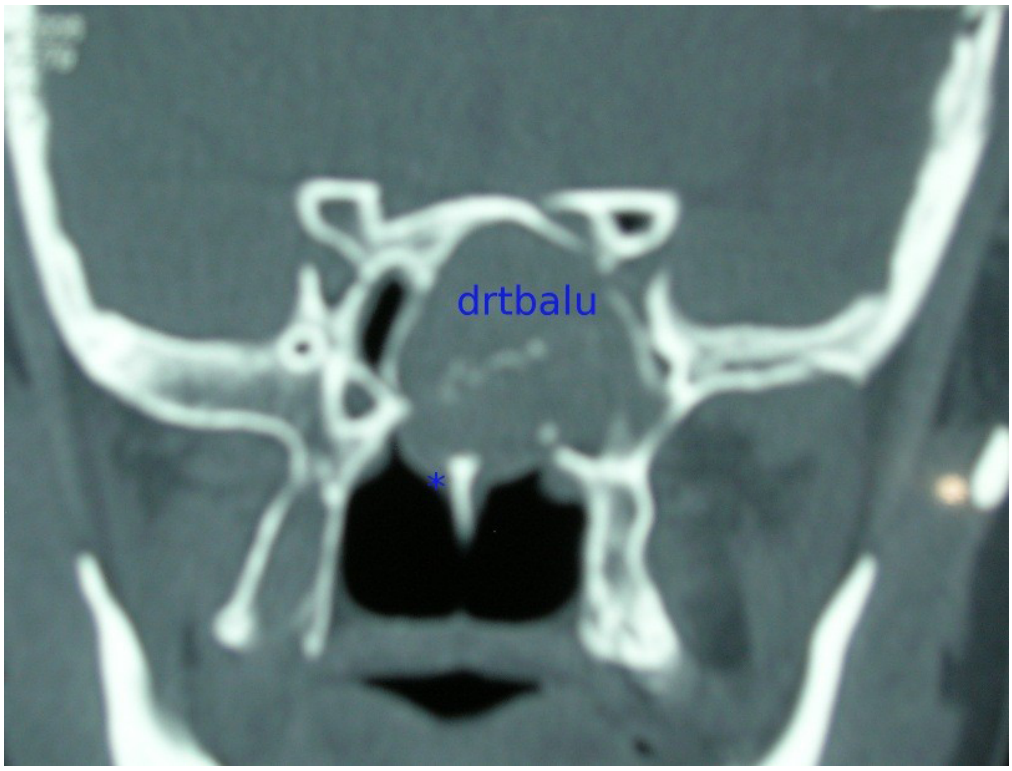
Meticulous pre operative review of CT and MRI scans of the patient. A CT scan picture not only provides critical information about anatomical landmarks it also shows up the anatomical variations. While studying the CT scan images lamina papyracea should be looked for evidence of dehiscence.



Coronal CT image showing lamina papyracea

The degree of pneumatization of sphenoid sinus should be evaluated. This will reveal to the surgeon the exact amount of bone that must be drilled to reach the pathology.

The presence of onodi cells should be noted. This cell is a well pneumatized posterior ethmoidal cell extending up to the anterior wall of sphenoid sinus enclosing the optic nerve / carotid artery. Eventhough presence of onodi cell is not a contraindication for endoscopic skull base surgery it must be appreciated prior to surgery to avoid injury to this critical neurovascular bundle.

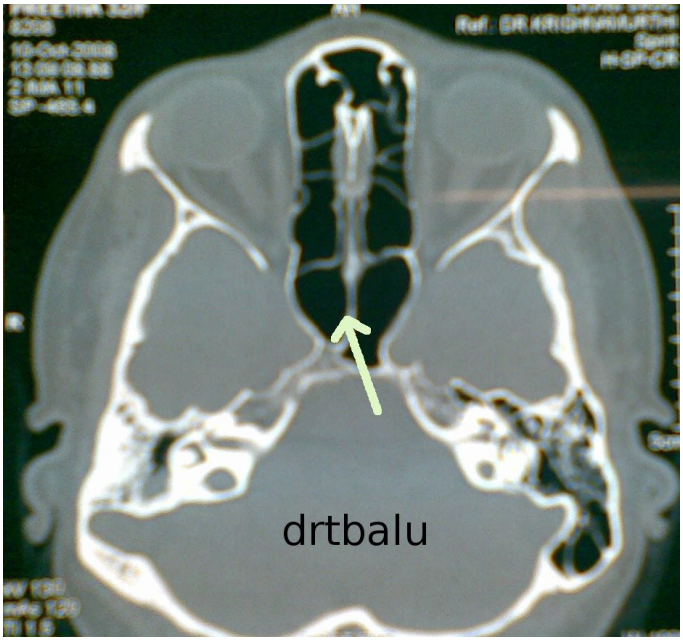


CT image showing sphenoid sinus

Axial CT image showing the onodi cell

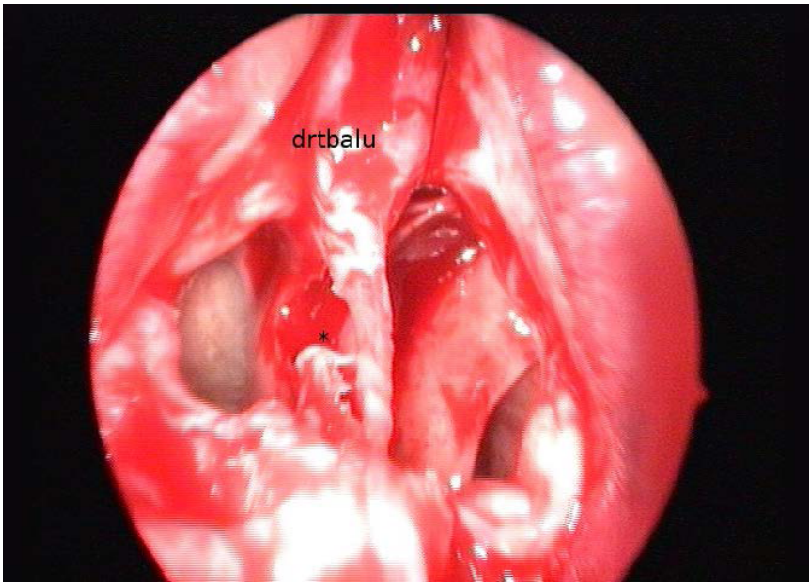
Intersphenoidal septae:

CT images should be utilized to look for the intersphenoidal septae. Usually there will be one bony septum separating the right from the left sphenoid sinuses. It may also be multiple / asymmetric also. The exact site of insertion of this septum in the posterior wall of sphenoid sinus serves as a valuable landmark in identifying internal carotid artery during surgery. If the image shows the carotid artery to be lateral to the insertion of septum then the surgeon can be sure of not damaging the artery if he stays medial to the septum. If the carotid artery lies medial to the septum then the surgeon will be forewarned about this anatomy. Rarely the septum may be attached to the carotid canal itself. In these cases the operating surgeon should not avulse the septum but should use true cut instruments to nibble it out. This will protect the carotid artery from inadvertant surgical trauma.



CT image showing the intersphnoidal septum

CT scan image showing asymmetric inter sphenoidal septum (arrow)



Picture showing endoscopic view of inter sphenoidal septum

Strict adherence to mucosal sparing technique:
While performing endoscopic skull base surgery it is important to maximally preserve the nasal mucosa by resorting to minimal access technique. It is also prudent to retain the middle turbinate during the surgical procedure. Simple gentle lateralization of it is sufficient to improve access to the surgical area. This mucosal preservation technique allows the nasal mucociliary mechanism to recover at the earliest with minimal crust formation. The presence of an intact nasal mucociliary mechanism will help in preventing infections. Excessive denudation of nasal mucosa will eventually lead to crust formation, atrophic changes, and synechiae formation. If need arises a nasoseptal flap can be harvested to close troublesome CSF leaks, in these patients the sphenoid sinus should be exposed and denuded off its mucosa in order to prevent mucocele formation.

Use of intraoperative doppler ultrasound to localize carotid artery:
This is very useful in removing the bony covering over the internal carotid artery and when the anterior wall of cavernous sinus is exposed. Doppler is superior to image guidance because of its ability to measure blood flow in real time. This will really ensure that the surgeon is not lost within the sphenoid sinus.

Identification of intraoperative CSF leak using intrathecal fluorescein dye:
CSF leaks are common complication of endoscopic skull base surgery and must be repaired at the earliest to prevent intracranial infections. Identification of CSF leaks on the table while performing surgery is virtually impossible. The so called "wash out sign" is highly unreliable. Intrathecal administration of fluorescein dye will help in identifying CSF leaks on the table. 0.25 ml of 10% fluorescein mixed in 10 ml of CSF is injected intrathecally before surgery. Leaks if any identified on the table should be closed primarily under endoscopic guidance. Studies reveal a success rate of more than 90% when these leaks are closed primarily, with the added advantage of avoiding second look surgical procedure. Ideal aim of any CSF leak repair is to create water tight separation between sinonasal cavity and intracranial contents. Multilayered closure of skull base defects really helps in creating this watertight compartment between sinonasal cavity and intracranial contents. Multilayered closure include:

1. Fascia lata layer
2. Rigid bone like vomer (supporting material)
3. Naso septal flap
4. Layer of tissue sealant

Obliterating dead space created by removal of tumor:
This is another vital step necessary to avoid potential complications. Dead space after tumor removal should be filled with abdominal fat.

Use of lumbar drain post operatively to reduce CSF pressure:
Placement of lumbar drain post operatively helps to reduce CSF pressure thereby minimizing CSF leak. Placement of lumbar drain in indicated under the following scenario:

1. Pathology of the tumor
2. Size of the tumor
3. Size of the skull defect
4. Presence of post op hydrocephalus
5. Increase of CSF pressure post operatively

Lumbar drain is an absolute indication if the tumor is suspected to be malignant in nature. If the tumor happens to be meningioma / craniopharyngeoma then a wide opening need to be created at the arachnoid cistern for their complete removal. This leads to an increase in the risk of CSF leak.

Periodic post operative cleansing of nasal cavity by removal of crusts, clot and other debris will help in minimizing the risk of complications.

Early intraopeative identification of critical neuro vascular structures will help in minimizing complications. If possible the blood supply to the tumor should be controlled before starting the debulking procedure. Tumors should first be debulked before trying to dissect its periphery. This procedure is followed meticulously will help in complete tumor removal without damaging the adjacent vital structures.

Role of neuroanesthesia in preventing complications:

In neuroanesthesia instead of hypotensive anesthesia the patient is maintained in a slightly hypertensive level in order to maintain cerebral perfusion rate. Intra arterial blood pressure monitoring (in real time) and central venous catheterization for administration of fluids and drugs is a must. Intraoperative monitoring of somatosensory potentials is a must. This will ensure adequate monitoring of the muscle tissues supplied by cranial nerves.

Real time Intraoperative image guidance systems:

This is another vital equipment which is used to minimize complications during endoscopic skull base surgery. Since the intranasal anatomy is highly variable it is imperative on the part of the surgeon to closely monitor the exact location of surgery. This is made possible by real time image guidance systems. It is possible to identify and preserve critical structures and anticipate the position of blood vessels during surgery.

Use of specialized surgical instruments:

This is another vital area. Many of the endonasal instruments were designed for endoscopic sinus surgery and were found to be too short to reach the skull base or their angles insufficient for skull base access. Currently lot of modified equipments are available that have the excellent reach and capabilities of neurosurgical instruments. Instruments like bipolar cautery, high speed drills and ultrasonic aspirators have become longer to accomodate the nasal corridor approach.

Figure showing some of the instruments used in skull base surgery

Hemostasis:

Ensuring adequate hemostasis a must for any successful endoscopic skull base surgery. Bleeding will virtually make endoscopic vision useless. Adequate hemostasis can be acheived by using bipolar cautery, sharp dissection of tissues, avoiding blunt dissection and unnecessary traction. It should be borne in mind bleeding from tumors and its vasculature is unavoidable.
Low flow bleeding from mucosa, bone or veins can be controlled by warm saline irrigation. Warm water irrigation reduces low flow bleeding by:
1. Enhanced platelet activation
2. Reduction of interstitial oedema
3. Enhanced enzymatic activity which increases coagulation
Ideal temperature of saline used for irrigation is 40 degrees centigrade. Anything more than this will cause cerebral hyperthermia.
Brisk bleeding from dural venous sinuses should be arrested by using topical hemostatic agents like flowseal.
High flow arterial bleeds should always be cauterized. Liga clips can be applied to secure the bleeder. Two surgeon approach will help in improved visualization in cases of high flow arterial bleeds. One surgeon uses suction through the opposite nose to suck out blood while another surgeon operates through the other nasal cavity using endoscope to visualize the area.

Diagnostic and therapeutic sialendoscopy
An overview

Introduction:
Common disorders of salivary glands involve obstruction involving their ductal system. Salivary gland calculi comprises the most common cause of enlargement of salivary glands. Obstructions could be caused by the presence of calculi, strictures of the duct etc. Sialoendoscopy is the most preferred mode of treating obstructions involving major salivary glands. Major advantage of this procedure is that it can be performed under local anesthesia as an office procedure.

History:
It was Konigsberger and his colleagues first used sialoendoscopy and lithotripsy to treat salivary gland calculi in 1990. During the year 1991 Gundlach and colleagues published their experience of doing sialoendoscopic procedures. Katz in 1991 used a 0.8 mm flexible endoscope to diagnose sialolithiasis and to remove them from major salivary glands. It was Kongisberger and colleagues who successfully used a flexible mini endoscope and intracorporeal lithotriptor to fragment major salivary gland calculi, thus opening up new vistas.

In 1994 Arzoz and his colleagues first introduced a 2.1 mm rigid endoscope which had a 1mm working channel as sialendoscope. This was indeed a mini urethroscope. They also used a Pneumoballistic lithotriptor along with this endoscope to hit the calculus and break it. This work was followed by Nahlieli who published his three years experience with rigid sialendoscope in the year 2000.

Instrumentation:
The diameter of the salivary duct sets the limit for the size of the instruments that can be used within them. The mini endoscopes that are used for cannulating the salivary gland duct can be divided into:
1. Flexible – The unique advantage of this endoscope is its flexibility making it easy to negotiate the kinks and bends present in the salivary gland duct. These flexible scopes cause lesser trauma to the duct. A major disadvantage is that it cannot be pushed through a stenotic segment of a duct. Its pushability is rather limited. Handling is also difficult. They are also very fragile and have a short life span when compared to the rigid and semirigid counterparts.
2. Rigid – These scopes have larger diameter and hence more stable. Its pushability is rather good. The image produced has excellent resolution. A camera can be attached to the scope making recording process rather simple. One major advantage of these scopes is that they can be autoclaved.
3. Semirigid - This has been recently introduced. It has a small diameter, offers a clear view and because of its semirigid nature has good atraumatic pushability making it easy to introduce it into the ducts of major salivary glands.
Semirigid scopes are of two types: Semirigid compact and Semirigid modular scopes.

Semirigid compact sialendoscope:

This system can be used for therapeutic purposes. The components of this system are:
1. Compact semi rigid endoscope
2. Fibreoptic light transmission system
3. Working channel
4. Irrigation channel
5. Fibreoptic image transmission system
6. The outer tube covers, stabilizes and protects all these components without adding on to the diameter of the whole system

Semirigid modular endoscopes:

In this type of endoscope the fibers used for transmitting light and images are combined to form a single proble like instrument. This probe can be used in combination with different sheaths. Using a small single sheath would create a diagnostic endoscope. The gap existing between the outer sheath and the optical system can be used as irrigation channel. If a single large lumen sheath / double lumen sheath is used then the whole system transforms into a potent surgical tool. The space inside the lumen can be used for introduction of various instruments. Major drawback of these modular systems is that sometimes air may get entrapped into the channel blurring the field of vision.

Advantages of modular endoscopes:

1. Economy – The optical system is the most expensive part of any endoscopic system. In this model the same system can be used for a variety of procedures. The same optical system can be combined with different sheaths there by creating a versatile tool.
2. Hygenic – Since the space between the sheath and the optical system is adeqate for cleaning the system the scope can be cleaned easily there by ensuring hygeine. In comparison the compact endoscopes have very thin irrigation channel making it difficult to clean. Plasma sterilization invariably is inadequate to sterilize these scopes.

The recent modular endoscopes are made of Nitinol steel which is more flexible than conventional steel. It is highly advantageous while maneuvering a tortuous salivary gland duct. It should always be borne in mind that a more rigid system is easier to steer.

Role of outer diameter of the endoscope:

This is the most important factor that determines whether the scope can negotiate the narrow channels of salivary gland ductal system. These scopes are usually 1.5 mm in circumference. It is this size that makes it easy for the scope to negotiate salivary gland ductal system. Some of the semi rigid scopes made by Karl Storz have a slight bend near its tip, this feature helps the scope in negotiating the branches of the ducts easier. This bend ofcourse has its drawbacks. It reduces the effective diameter of the sheath there by making it difficult for insertion of straight surgical instruments via the portal. The intraductal postion of these scopes can easily be ascertained by the transillumination effect created over the skin. The shaft of the endoscope is provided with markings which indicates the distance the scope has been introduced into the ductal system.

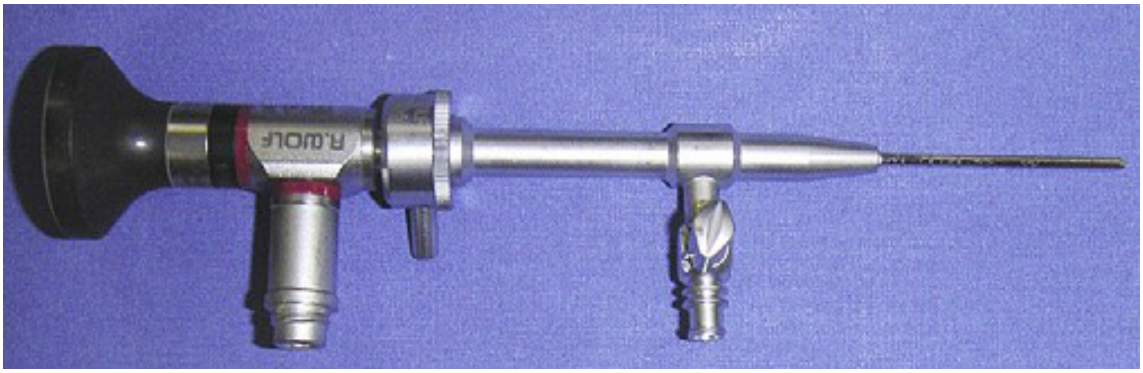
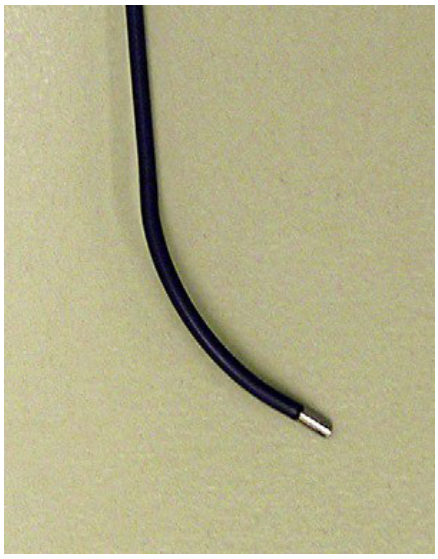


Image showing Sialendoscope

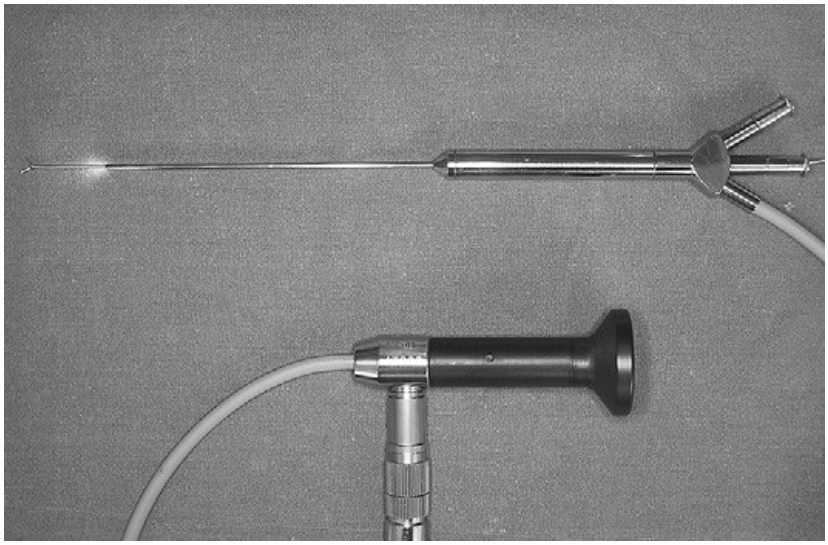
Diameter of working channel:

This aspect is important inorder to perform certain specialized therapeutic tasks using sialendoscope. The working diameter has a direct effect on the stability of the instrument used in sialendoscopic therapeutics. Working channel diameter of 0.8 mm is a must for using instruments such as forceps, balloons, or baskets. These instruments occupy about 0.4 mm of this working channel space. Studies have shown that the incidence of metal fatigue is directly correlated with this diameter. The smaller this diameter more the chance of metal fatigue.



Semiflexible sialendoscope with a bent tip

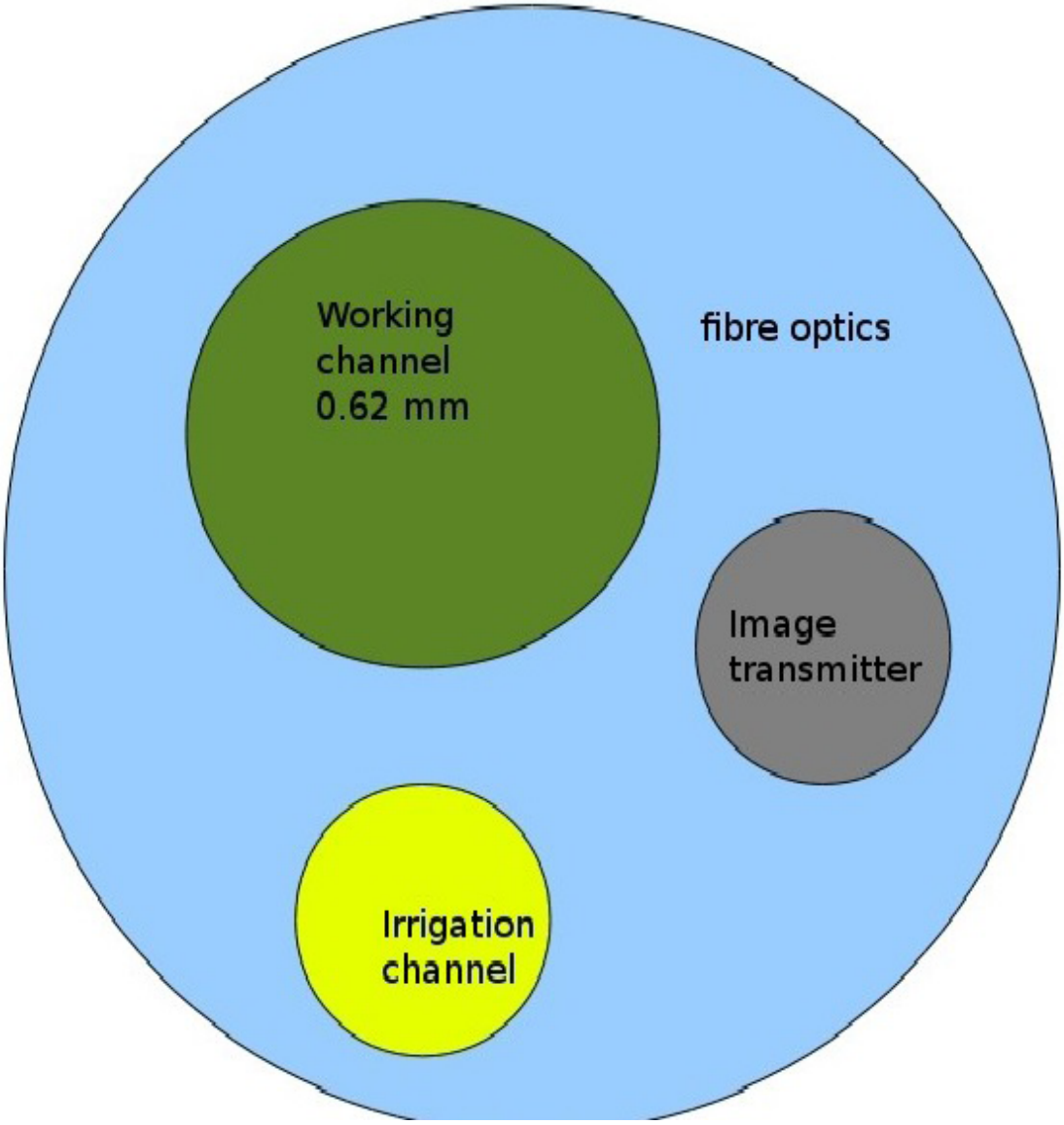
Sterilization procedures for sialendoscopes:
Sialendoscopes are highly fragile instuments. Since these instruments when used for diagnostic purposes come into contact with intact mucosa semicritical sterilization procedures like wiping the scope with savlon / spirit gauze would be sufficient.
Scopes used for therapeutic purposes should be autoclaved. Since these instruments are highly fragile only limited number of autoclave cycles can be performed.



Semirigid therapeutic sialendoscope

Image resolution produced by sialendoscopy system:
Image resolution of sialendoscopy system is very good because of dense packing of optical fibers. Most modern sialdendoscopes have a resolution of 6000 pixels.

Instruments used in therapeutic sialendoscopy:
Forceps:
Two types of forceps are available:
1. Grasping forceps with serrated edges. These forceps are useful in dilating the ducts and grasping and removing small stone fragments after crushing the calculus.
2. Cup forceps with sharp edges. This forceps is useful in crushing calculus and taking biopsy of suspicious tissue.
These two forceps can easily be attached to an universal handle. Ideally the handle which allows rotation of the tip of the forceps is considered to be advantageous.



Diagramatic representation of the tip of therapeutic semirigid sialendoscope

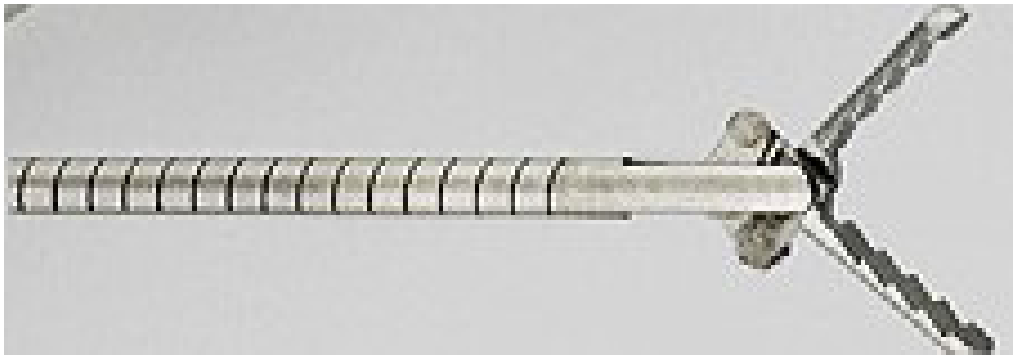


Figure showing toothed forceps

Figure showing universal handle

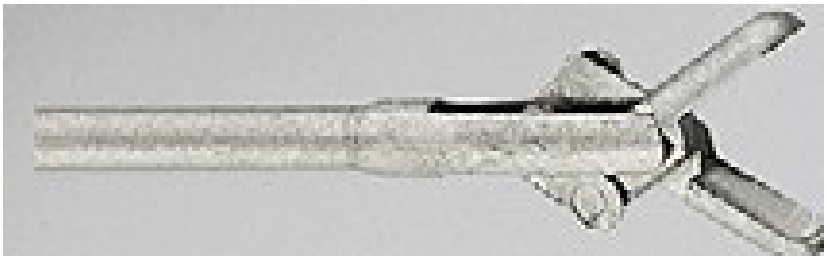


Image showing biopsy forceps with cutting edges

Baskets:

Baskets are very useful in removing salivary gland calculi. These baskets are classified according to:
1. Number and form of their wires
2. Type of tips
3. Presence or absence of outer sheath
These baskets can be attached to the universal handle provided. These handles need not provide rotatory movement of the tip of the basket compared to the ones used along with forceps.
Baskets with higher number of wires (more than 4) are very useful in removing small stones.
Baskets made of strong wires (made of nitinol steel) are very useful in dilating the salivary gland duct and in negotiating the stenotic segment.

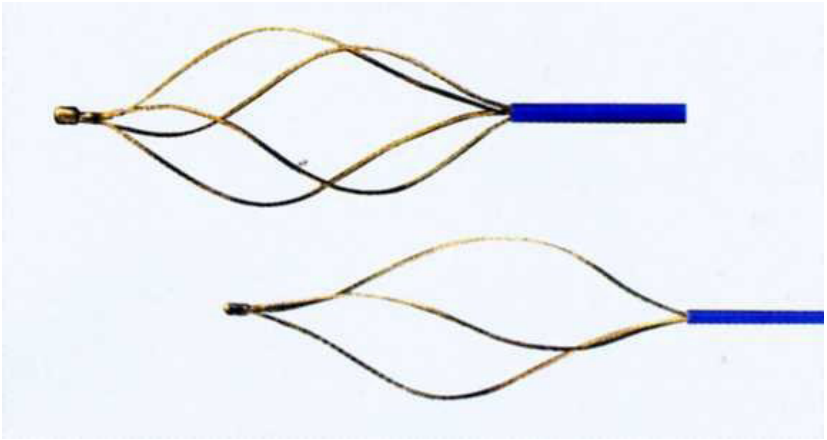


Image showing a typical basket forceps

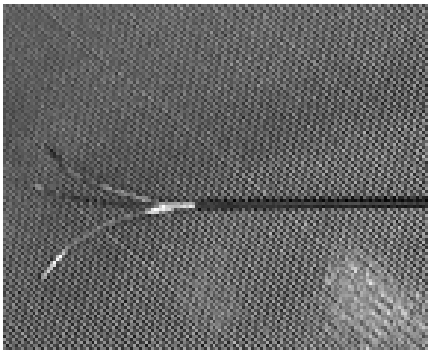


Image showing a grasper

Image showing solex soft lumen expander

Graspers:
This is a mixture of forceps and basket. But its use is highly limited. This instrument is slowly finding its way out because of the propensity to traumatize
the ductal mucosa. This invariably leads to ductal stenosis after the procedure which is a highly unwelcome complication.

Dilators:
These dilators are conical in shape and are used in the identification of the papillae and duct of major salivary glands. Two types of dilators are available:
1. Conical sharp dilator is useful in the initial identification and dilatation of the salivary duct papillae

2. Conical blunt dilator which can be introduced into the duct after the identification and dilatation of the papilla. Conical sharp dilators when used inside the ducts can cause trauma to the ductal mucosa and hence are best avoided in this scenario.

Solex soft lumen expanders:
The advantage of this instrument is that it is available in different sizes. It contains an outer sheath and an inner dilator. The advantage of this system is that after dilatation the inner probe can be removed leaving the outer sheath in the duct. Sialendoscope can easily be passed through this sheath, and calculi if any can be removed. Major advantage of leaving the outer sheath is that it prevents damage to the ductal mucosa while the calculus is being removed.

Image showing solex soft lumen expander

Drills and micromotor system:

Microdrills play a vital role in fragmenting the salivary gland calculi there by facilitating easy atraumatic removal. These microburrs have a diameter of 0.38 – 0.4 mm.

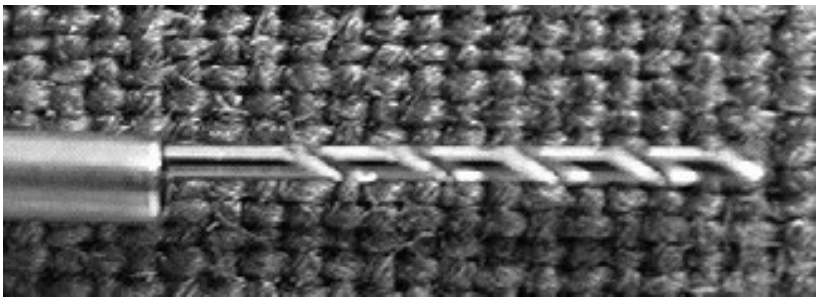


Figure showing microburr tip used to fragment salivary duct calculi

Balloons:
These are of two types:
1. Low pressure type – This balloon expands rapidly with minimal insufflation. These balloons are of limited use because of their propensity to rupture easily. They are useful in dilating thin membranous areas.
2. High pressure balloon – These are commonly used. They need a special syringe system for inflation. Major advantage of this high pressure balloon is that they can easily be introduced via the sialendoscope port. Some of these high pressure balloons have sharp cutting margins and hence are very useful in fragmenting large salivary ductal calculi.
Cytology Brushes:
These brushes were originally designed to take biopsy from ducts of mammary glands. These brushes can be used to harvest cells from inaccesible areas of salivary glands there by facilitating tissue diagnosis. These brushes have been designed in such a way that they can easily pass through the portal of a sialendoscope. These brushes need to be handled with great care as they are very flimsy and can easily be damaged.

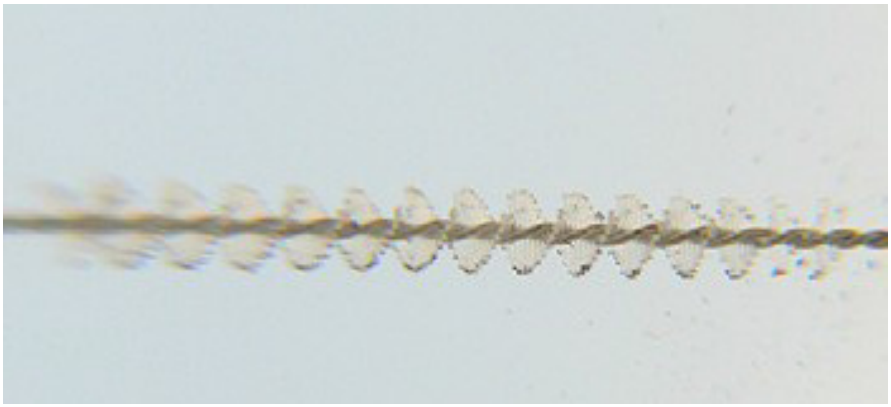


Image showing a cytology brush

Indications:
1. Diagnostic
2. Therapeutic
Diagnostic indications include any suspected obstructive salivary gland disease.
Therapeutic indications:
1. Treatment of salivary gland calculi which involves localization fragmentation and removal. It may also be used as a guide for external approach calculi removal.
2. Localization and dilatation of strictures.
3. In managing chronic sialadenitis by irrigation
4. In the management of recurrent juvenile sialdenitis

Diagnostic sialendoscopy:
Before embarking on this procedure a detailed patient history should be taken. Pointers in the history that could suggest obstructive salivary gland disease include:
1. History of glandular swelling associated with food intake.
2. Glandular swelling associated with pain

Ultrasonic examination is a must before diagnostic sialendoscopy. Before ultrasonic examination if a sialagogue is administered it would go a long way in assessing the cause and region of salivary gland obstructive pathology. Eventhough ultrasound examination would clinch the diagnosis in majority of cases it could create difficulties in the following scenario:

1. Ultrasonic examination fails to distinguish between non echogenic stone and stricture. In this scenario diagnostic sialendscopy helps in arriving at a diagnosis.
2. Ultrasonic examination fails in the quantitative assessment of salivary gland obstruction, because ultrasound doesnot precisely assess the three dimensional size of the salivary gland calculus. It also fails to assess the extent of stenotic segment or their number in cases of multiple stenosis.
3. If intraductal removal of calculi is planned then ultrasound exam is not suited because it cannot precisely assess the diameter of the duct.

Sialogram:
This investigation helps in the accurate assessment of the complete ductal system of the salivary gland. This is much better than sialendoscopy because it images the complete ductal system. Major disadvantages of sialography is that it can expose the patient to unnecessary radiation. It can also show false positives in the presence of air bubbles which may be mistaken for salivary gland calculus.
The advantage of sialendoscopy in these patients is that it can effortlessly be switched to the therapeutic mode in the same session.
Diagnostic sialendoscopy:
The advantage of this procedure is that it can be performed under local anesthesia. The mucosa of oral cavity can be anesthetized by topical use of 4% xylocaine. Additional infiltration anesthesia of the ductal area can be achieved by infiltration with 2% xylocaine with 1 in 10,00000 units adrenaline.

Step I:
Dilatation of the papilla of salivary gland duct. This can be achieved by insertion of a sharp conical dilator. Further dilatation is possible by the introduction of a blunt conical dilator. If the papilla is stenosed / narrowed due to persistent inflammation then papillotomy may have to be resorted to.
Step II:
Creation of artificial cavity. As performed in abdominal laparoscopic procedures an artificial cavity will have to be created to enable easy passage of sialendoscope. This cavity creation is achieved by irrigation of isotonic saline via the duct. The saline irrigated should be mixed with 4% xylocaine. The saline lubricates the duct of the gland facilitating easy passage of sialendoscope. The local anesthetic mixed with saline takes away the pain and discomfort of insertion.

Step III:
The outer sheath of sialendoscope is inserted via the major salivary gland duct. The endoscope follows later. The endoscope is attached to an endocamera which faithfully captures the image and projects it on a digital monitor. It should be borne in mind that a sphincter system is present near the papilla of Wharton's duct. Any damage to this system may lead to unnecessary salivary drooling. Papillotomy should be avoided in wharton's duct. The same sphincter system of Stenson's duct is located posteriorly hence papillotomy of stenson's duct will not cause sphincter problems. Before introduction of the endoscope the zero position of the scope should be ascertained by focussing on a letter. It is also prudent to orient onself to the direction of the instrument channel of the sialendoscope before the actual introduction.
When performing sialendoscopy of submandibular salivary gland the sublingual salivary gland duct could be seen opening in to the anterior part of wharton's duct. This opening usually lies 5 mm posterior to the papilla. This is one of the reasons for avoiding papillotomy in wharton's duct.
While performing sialendoscopy the lining mucosa of the ductal system should be carefully examined. In a healthy gland the ductal mucosa appears shiny and the underlying blood vessels can be clearly seen. In salivary glands affected by chronic sialadenitis the mucosal lining of the duct shows matted appearance with submucosal ecchymosis.
The presence of intraductal calculi if any should be documented. In wharton's duct the calculi are usually seen at its bifurcation. This bifurcation is present because of the presence of two portions (superficial and deep lobes of the submandibular gland). In parotid duct calculi usually lie posterior to its curvature.

Ductal polypi:
Ductal polypi when present will be seen as filling defects in a sialogram. They can be clearly seen in sialendoscopy and if necessary biopsy can also be performed.
Intraparenchymal sialoliths:
Presence of sialoliths in the parenchyma of salivary glands can also be observed if present close / adjacent to the ductal system.
Occult radiolucent calculi:
It should be borne in mind that nearly 70% of parotid gland calculi are radiolucent and quarter of submandibular calculi are radiolucent. Diagnosis of radiolucent calculi can be made only by observing filling defects in a sialogram or by direct visualization through sialendoscope.
Kink's and strictures:
Kink's and stricutres present in the salivary gland ductal system can be observed best in a sialogram. The same may be confirmed by performing sialendoscopy.
Presence of pelvis like ductal formation of wharton's duct:
This is one of the rare congenital anamolies that can be picked up while performing sialendoscopy. Instead of the routinely seen bifurcation / trifurcation the main duct assumes a pelvis like formation thus leading to obstruction in the drainage of saliva.
Presence of intraductal foreign bodies like hair, tea leaves can also be identified and if possible can also be removed.

Therapeutic sialendoscopy:
Eventhough sialendoscopy has been used for therapeutic purposes it should at best be considered to be an adjunt visual control of therapeutic procedures.
Sialendoscopy can be effectively used in dilatation of salivary duct strictures.
Dilators rigid / balloon types can be used for the same.
Role of sialendoscopy in the management of salivary gland calculi:
The aim in the management of sialolithiasis is to remove the calculus completely. Sialendoscopy should be considered as one of the many management modalities available. Calculi of submandibular gland measuring less than 4 mm can be removed under sialendoscopic vision using basket. Similarly calculi measuring 3 mm and below can be removed using the same technique from parotid duct. Any calculi measuring more than the above mentioned size needs to be broken down into small manageable bits using either crushing forceps or extracorporeal / laser lithotripsy. When the calculi has been shattered to smaller manageable bits they can be removed transluminally under endoscopic visualization. Normal submandibular and parotid ducts measure 1.5 mm with the narrowest portion being 0.5 mm at the level of papilla. Hence the stone's diameter which can be handled by sialendoscopy should not be larger than 150% of the diameter of the anterior ducts.
Before attempting to remove salivary gland calculi conservatively patients should be encouraged to take sialogogues like bubble gum and the enlarged gland can be massaged in an attempt to flush out the calculi from the duct. Only when this conservative approach fails other invasive modalities of treatment should be considered.
Management of chronic sialadenitis:
Sialendoscopes can be used to clear mucous plugs which are a common feature of chronic sialadenitis. The duct also can be dilated by irrigation of normal saline through the ductal system.

Difficult scenario:
Therapeutic endoscopes may be large and would have difficulty in negotiating the major salivary gland ductal system. In these cases a modified Seldinger technique can be attempted. The papilla of the duct is dilated and then the outer sheath of the scope is passed through it.
The instrument used for calculi removal (guide wire, basket) etc is passed through it while the endoscope follows the same.
Side effects of therapeutic endoscopy:
1. Temporary swelling due to irrigation of the duct
2. Perforation of ductal wall
3. Wire basket blocks
4. Lingual nerve paraesthesia
5. Ranula
6. Ductal strictures
7. Post op infections

Coblation Tonsillectomy

Introduction:

Tonsillectomy still remains the commonly performed surgical procedure. Surgical technique of tonsillectomy has undergone rapid evolution since the time of Celsus 30 BC who is credited with the first documented tonsillectomy procedure. Hook and knife method performed by Aetius of Amida during 6th century shoud be considered as the first scientific attempt at removing tonsils. Paul of Aegina used forceps to completely extripate tonsils. This laid the foundation for tonsil guillotine. George Earnest Waugh of England was the first to use careful dissection method to remove the tonsil. He is also credited with the design of Waugh's tenaculum forceps which he used to dissect tonsil out of its bed (1909). Innovations that took place like the use of diathermy, harmonic scalpel, debrider were meant to reduce the operating time and bleeding during the procedure.
Currently coblation is being attempted to remove tonsillar tissue. This process was invented by Philip E Eggers and Hira V Thapliyal in 1999. Coblation tonsillectomy received FDA approval in 2001.

Advantages of coblation tonsillectomy:

1. Less bleeding
2. Preservation of capsule is possible if done under magnification. If capsule is preserved there is less post operative pain
3. Tonsillar reduction surgeries can be performed in young children without compromising the immunological function of the lymphoid tissue

The technology:
Coblation involves passing a radiofrequency bipolar electrical current at a much lower frequency than that of standard bipolar diathermy, through a medium of normal saline which results in the production of plasma field of sodium ions. These ions breaksdown intercellular bands and in effect vaporize tissue at a temperature of only 60degrees c. The presence of saline helps to limit the amount of heat delivered to the surrounding structures and hence reduces collateral tissue damage and causes less post op pain. This is truely a bipolar system and does not need earth pad.

Methadology:
This study involves 25 patients who underwent coblation tonsillectomy. They were compared with patients who underwent cold steel tonsillectomy. This is a retrospective study involving 25 patients who underwent coblation tonsillectomy by a single surgeon (the author). The results were compared with that of cold steel tonsillectomy surgery performed by the same surgeon.

Selection criteria:
1. Random selection of patients by draw of lots
2. Children of the age group between 5-10 constituted the subjects of study
3. This study involved 50 patients out of whom 25 underwent coblation tonsillectomy while the rest underwent conventional cold steel tonsillectomy.

Data taken for analysis include:

1. Age
2. Amount of blood loss
3. Pain score
4. Post operative bleeding

Follow up was preformed by a second surgeon who did not know what procedure was followed during tonsillectomy. Each of these patients were asked to fill up a questionaire which cotained specific questions relating to the time taken for them to return back to normal life.

Statistical tools were not used to analyze the data because the study number was small.

Results:

Total number of cases taken up for study = 50
Number of patients who underwent coblation tonsillectomy = 25
Number of patients who underwent conventional cold steel tonsillectomy = 25
Average Age distribution of patients who underwent coblation tonsillectomy was = 7.16
Average Age distribution of patients who underwent conventional cold steel tonsillectomy = 7.2
Age distribution between the two study categories were more or less similar.

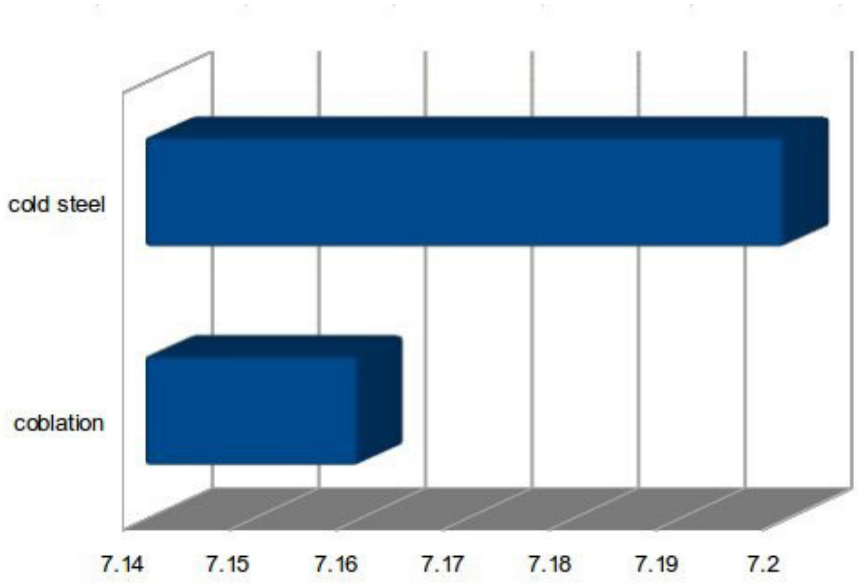


Figure showing age distribution between two study groups

Assessment of blood loss during these two procedures:
Cotton balls and gauze planned to be used during surgery should be carefully weighed before autoclaving. Used cotton and gauze should be weighed and the difference in weight is an assessment of blood contained in them. The difference in weight can be converted into milliliters by dividing the difference in weight by specific gravity (1.055). 4
Saline taken in the bowl is measured and kept at 150 ml. This volume is used to keep the suction tube unclogged. This volume should be subtracted from the volume of blood inside the suction bottle. This volume added to the volume of blood loss estimated from cotton and gauze gives the volume of blood loss during the procedure.
All patients were premedicated with injection atropine which helped in reducing normal salivary secretions. Oral cavities of these patients were cleaned dry using gauze before the start of procedure.

Average blood loss of these patients was:
Coblation tonsillectomy = 86 ml
Cold steel tonsillectomy = 90 ml
These values indicate that there was no appreciable difference in blood loss between these two groups.

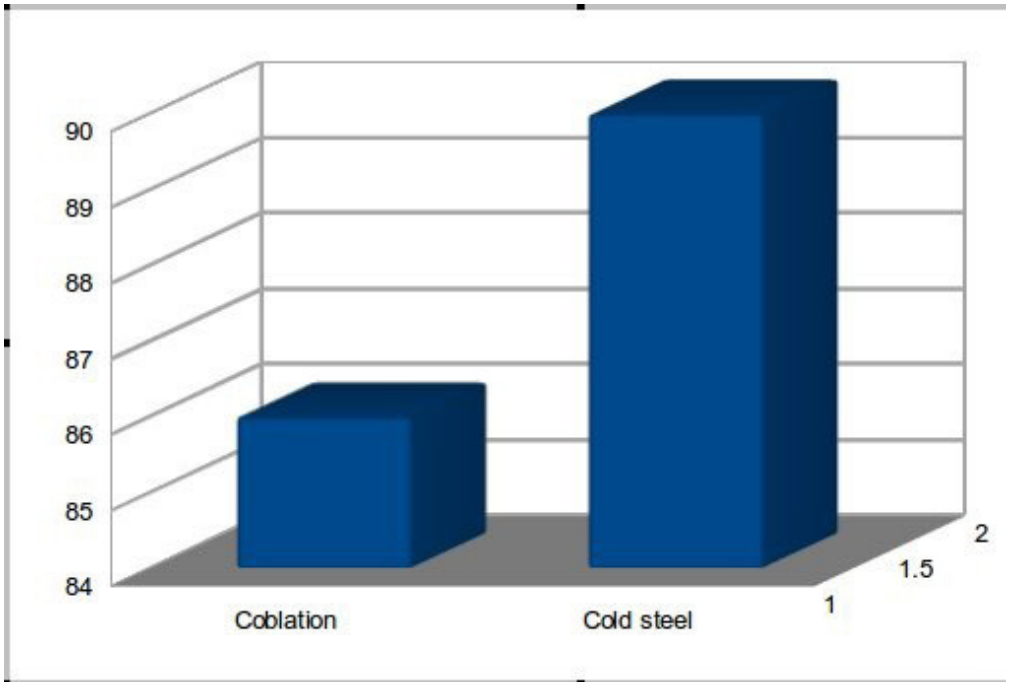


Figure showing comparison of blood loss between coblation and cold steel tonsillectomy groups

Pain score:
Pain score was calculated using Wong-Baker FACES Pain Rating scale. One child of age 3 who underwent tonsillectomy was excluded from the study since the response was unreliable.
The child is shown image containing 6 faces and is asked to choose which best describes his / her current feeling.

Figure showing Pain rating scale (Wong- Baker) used in this study

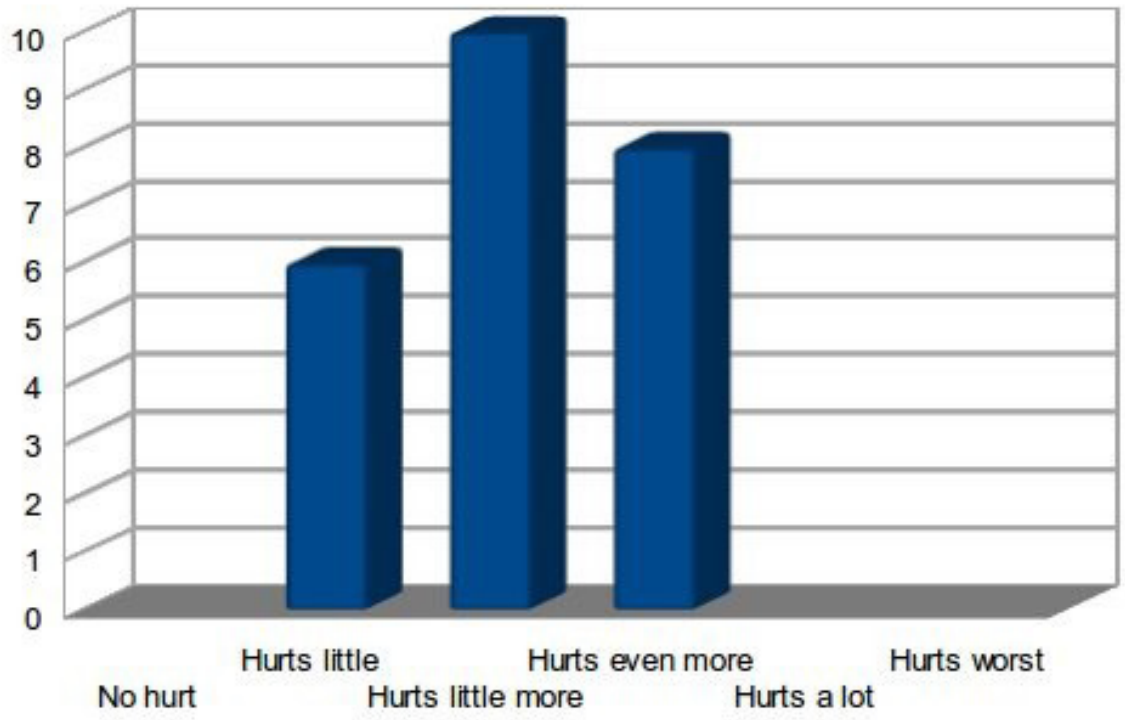
Coblation tonsillectomy group:

1. 6 patients choose image 2
2. 10 patients choose image 3
3. 8 patients choose image 4

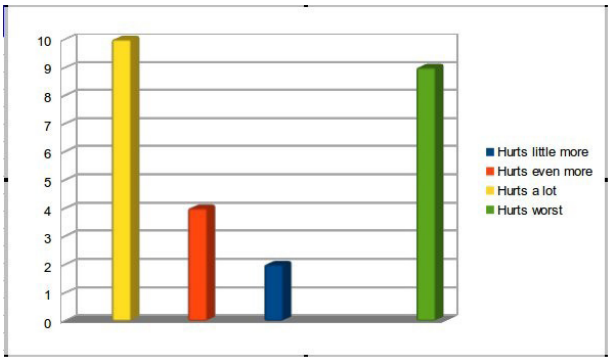
1 patient was excluded since the child was 3 years old

Cold steel tonsillectomy group:

1. 10 patients choose image 5
2. 4 patients choose image 4
3. 2 patients choose image 3
4. 9 patients choose image 6



Pain score in coblation group



Pain score in cold steel tonsillectomy group

Pain scores were found to be rather high in patients who under went cold steel tonsillectomy. This could be attributed to the extracapsular dissection which is done in coblation. Leaving behind tonsillar capsule has been postulated to reduce pain because there is less muscle exposure and irritation. Pain due to tonsillectomy has been attributed due to pharyngeal muscle spasm which is commonly seen when the muscle fibers are exposed.

Post operative bleeding:
Our study did not show any post operative bleeding in the cold steel tonsillectomy group. One patient belonging to coblation group developed secondary bleeding on the 8th day following surgery. Patient recovered on being treated with antibiotics 5. Noon et al in their study have reported a greater incidence of post op bleeding in patients who have undergone coblation tonsillectomy. 6 They attributed this to the formation of healthy granulation tissue in the tonsillar fossa which had a tendency to bleed even on trivial trauma.

Discussion:

Coblation tonsillectomy is a recent innovation. It has evoked a lot of curiosity among otolaryngologists. Tonsillectomy has been performed commonly worldwide.
Experience with coblation is quite recent. More and more literature is being generated world wide by people using this technology. Even though this study is limited by the number of patients studied, it gives a clear pointer to one aspect i.e. coblation tonsillectomy causes less post operative pain when compared to conventional cold steel procedure. This is due to the fact that tonsillectomy using this procedure is extracapsular. Debulking of enlarged tonsils can also be performed preserving the immunological functions of the tonsils. This study showed no evidence of lesser post operative bleeding between the two groups under study.

Conclusion:

Coblation is a promising technology for otolaryngological use. Major advantage the author noticed while performing tonsillectomy is reduced post operative pain scores. Patients started eating with very little discomfort following surgery. A more comprehesive study would throw more light on this technology.

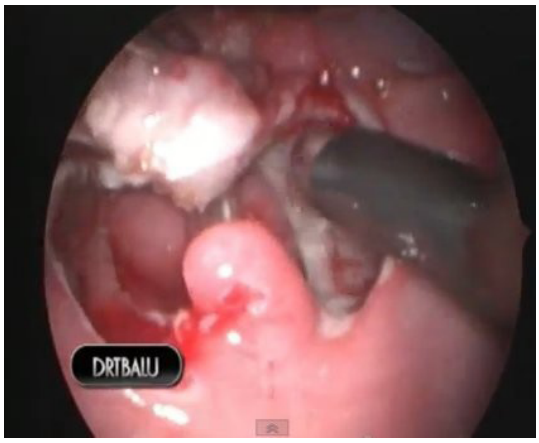


Figure showing coblation tonsillectomy

Role of optical diagnostics in the early detection of oral mucosal cancers

Introduction:

When light passes through tissue it undergoes various modifications depending on tissue biological properties. Analysis of this light will provide vital insights into the physiological condtion of the tissue at a molecular level. This property of light is made use of in early diagnosis of superficial mucosal malignant lesions. Studies have demonstrated that many of the biological events leading on to development of malignancies also alter the optical properties of the tissue causing them to produce characteristic optical signatures which can be easily recorded. Various types of light based detection systems have been developed to identify these optical signatures.

Advantages of optical diagnostic system:

It is non invasive
It can precisely identify suspicious lesions for specific biopsy procedures to be performed
It has the potential to provide real time tissue assessment

Types of optical diagnostic system:

Spectoscopy
Fluorescence spectroscopy
Elastic scattering spectroscopy
Raman spectroscopy
Fluorescence imaging
Optical coherence tomography
Narrow band imaging
Multimodal optical imaging

Spectroscopy:

This method is used to analyse the changes undergone by light passing through tissue. The tissue while undergoing changes from normal to neoplasia undergoes complex molecular transformation. These transformations modifies the manner in which light is absorbed / reflected from the tissue. While performing spectroscopic analysis of tissue, the light of specific wave length is delivered to the tissue via an optical probe. The spectral pattern produced by the light reacting with the tissue is analysed for light – tissue interactions.

Fluorescence spectroscopy:

This study is based on biological emission of fluorescent light when the tissue studied is exposed to ultraviolet / short wavelength visible light. Light is composed of energy packages known as photons. Tissues on being exposed to light may cause absorption / reflection / scattering of photons. Tissues are known to contain light reactive biomolecules known as fluoropores. These fluoropores absorb energy from light and emit fluorescent light of lower energy and longer wave length. Study of this emitted light from tissue will provide valuable insight of biological status of the tissue.
The concentration and distribution of fluorophores vary as the tissue undergoes malignant transformation. This becomes clearly evident in the spectroscopic pattern produced.

Elastic scattering spectroscopy:

This is also known as diffuse reflectance spectroscopy. Here white light (400 – 700 micrometer) is used to illuminate the tissue under study. Photons from this visible light gets reflected from the tissue without a change in wavelength / energy. The reflected light can be measured to look for changes. This reflected light is known as scattering. Tissues with malignant potential show different scattering pattern.

Raman spectroscopy:
This method can be used to provide detailed information about molecular composition of tissue. Raman spectra is generated by inelastic scattering of light which is highly molecule specific. The light source used is usually in the infra red spectrum. Infrared light on striking the tissue undergoes wavelength shift which is caused by energy transfer between incident photon and tissue molecules. This subtle shift in wavelength of light can be spectroscopically analysed.

Fluorescence imaging:
These system classically use the principle of spectroscopy to capture fluorescence emission from a larger surface area of tissue. The image is usually captured in real time using a camera. The tissue is illuminated with light source generating light in the uv range. These systems are capable of capturing images from large tissue areas.

Optical coherance tomography:
This imaging technique provides high resolution cross sectional images of the tissue studied. The technology involved is most similar to B scan (Ultrasound). This technique detects back scattered light waves after the tissue is probed with low power infrared light source. The optical probe used is about 2 mm in diameter. The tissue in study can be scanned in transverse / linear / radial fashion.

Narrow band imaging:
This technique helps in visualizing microvasculature of surface mucosa. Optical interference filters in red / green / blue range are used to limit the penetration of tissue by light. Hemoglobin is known to absorb blue light. Just by studying tissue absorption of blue spectrum of light an indirect assessment of vascularity of the tissue studied can be made. Since malignant transformation of tissue is assocaited with formation of new blood vessels this imaging modality shows clearly the malignant transformation of tissue.
Multimodal optical imaging:
These devices make use of 2 / more technologies descussed above. These devices can also be used to assess tissue in real time. Since it involves more than one spectroscopic imaging technique the results are fairly accurate.

Modified Septoplasty

Introduction:

Septoplasty is the commonly performed surgical procedure these days. It has been evolving for more than a century. It was in the early part of 20th century Freer and Killian first reported this procedure. The technique developed by them involved removal of the complete nasal septum (SMR). It was left to Cottle to fine tune their procedure of submucosal resection of nasal septum. During initial stages due to fear of complications and constraints of illumination septal deviations involving the anterior and middle portions alone were corrected adequately. Posterior deviations were left unattended. With the advent of excellent equipments like the nasal endoscope the whole of the nasal septum can be visualised and this led to removal of excess septal cartilage leading to complications like septal perforation, flappy nasal mucosa and nasal deformities like saddle nose etc. Inspite of being nearly a century old procedure the concepts governing septal surgery has undergone very few modifications. Metzenbaum recognized the importance of caudal portion of nasal septum and was instrumental in devising the first principles of septoplasty. His swinging door technique is still being followed with minor modifications in the septoplasty procedure performed even now.

Modified septoplasty procedure:
Wang etal suggested certain modifications in the currently performed septoplasty procedures. These modifications were aimed at:

Ability to deal with all types of septal deviations
Preservation of cartilagenous support framework
Avoidance of complications

Before suggesting these modifications they conducted extensive studies on the biomechanics of septal deviation. In their study they identified three key stress lines in the nasal septum. These stress lines are:

At the junction between the caudal septal cartilage and the medial crus of the alar cartilage. This often causes anterior deviation.
Between the quadrangular cartilage and the perpendicular plate of ethmoid. This often leads to superior deviation.
Between the quadrangular cartilage and vomer bone, palatine process of maxilla and nasal crest of palatine bone. Deviations in this area leads to inferior deviation.

The reasons for these stress lines can be accounted if the theory of differential septal ossification is considered to be the cause for septal deviation.
During the development of nasal septum uneven ossification of the various parts of the septum can occur. The developing nasal septum is supposed to contain a membranous component anteriorly and cartilagenous and osseous component posteriorly. The posterior portion of nasal septum ossifies and forms perpendicular plate of ethmoid, nasal crests of palatine and maxillary bones and the vomer. Studies have shown that the septal cartilage is still in the process of continuous growth even after full maturation of maxilla and palatine bones. Due to the space constraint the growing cartilagenous portion of the nasal septum buckles.

Diagram illustrating the three stress lines of nasal septum

During the development of nasal septum uneven ossification of the various parts of the septum can occur. The developing nasal septum is supposed to contain a membranous component anteriorly and cartilagenous and osseous component posteriorly. The posterior portion of nasal septum ossifies and forms perpendicular plate of ethmoid, nasal crests of palatine and maxillary bones and the vomer. Studies have shown that the septal cartilage is still in the process of continuous growth even after full maturation of maxilla and palatine bones. Due to the space constraint the growing cartilagenous portion of the nasal septum buckles.

In the modified procedure of septoplasty suggested by Wang etal the septum is surgically accessed via the standard Hemitransfixation incision. The septal cartilage is freed from its anterior, posterior and inferior attachements. Only the superior attachment is intact ensuring that the septal cartilage does'nt fall off. The cartilage can be shortened in order to fit in to the space. The shortening of the cartilage causes the septum to straighten. Since cartilage is fractured in order to correct the deviation healing takes a little longer. Splinting of the nasal septum is a must atleast for 10 days for optimal wound healing to occur.

Advantages of this modified procedure:

It maintains the thickness and rigidity of the nasal septum
Avoids synechiae formation
Prevents depression of nasal tip and pyramid
It reduces the incidence of septal perforation.
This procedure can safely be performed in adolescents also.

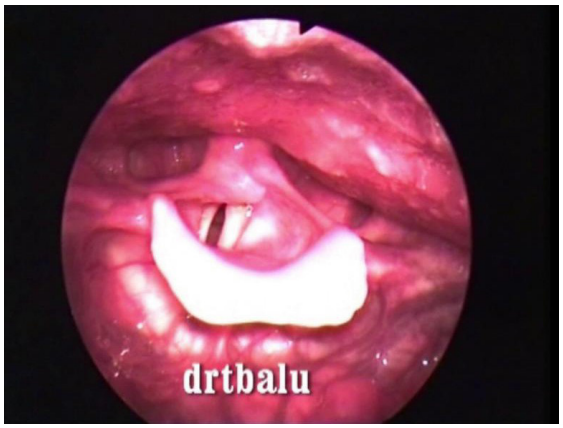
Gore tex medialization thyroplasty- A case series

Introduction:
Vocal fold paralysis is a rather common problem causing speech problems to the patient. If the other cord does not compensate adequately these patients may have troublesome aspiration also. Aspiration happens to be the most dreaded complication of vocal fold paralysis. Management of these patients is possible only by performing medialization thyroplasty. Various implants have been used in this procedure. Presently lot of interest has been generated in Gore tex medialization thyroplasty.

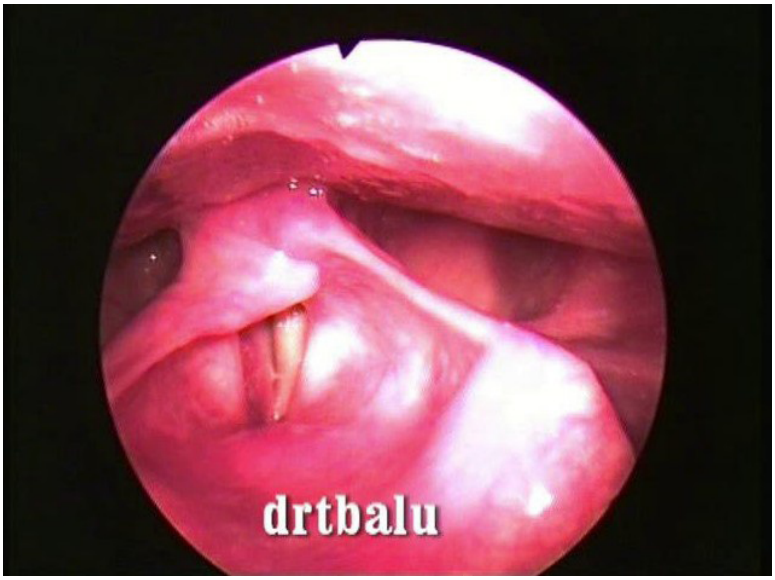
Materials and methods:
A study was conducted in Govt. stanley medical college, Chennai from the year 2009 to 2011. In the period we did 4 cases of medialization thyroplasty with Gore tex material. Cases were evaluated objectively and subjectively.

Inclusion criteria:
1.Unilateral vocal fold paralysis due to paralysis, paresis, atrophy.
2.Unilateral vocal fold scarring, soft tissue loss
3.In selected cases of parkinson's diseases with vocal fold atrophy.
Exclusion criteria:
1.Previous history of irradiation or surgery.
2.Malignant lesions involving larynx
3.Poor abduction of contralateral vocal fold.

Patient evaluation:
Objective measures:
1.videolaryngoscopic examination:
Videolaryngoscopic examination was done and recorded for all patients to compare pre operative with post operative vocal cord status. Glottic gap,overriding of arytenoid are noted.



Pre-op vocal fold status



Post operative VLS examination- disappearance of Glottic gap is seen

2. Maximal phonation time:
The average maximal phonation time of these patients is 6 seconds against normal value of 25 seconds. It is improved post operatively to 20 seconds.
3. Manual compression test:
Even though it is not specific manual compression test done and quality of voice is assessed.

Figure showing manual compression test

Subjective measures:

Patient's self evaluation:
1.Voice: And patients were followed up on 3 months and 6 months and the same quality of voice is assured.
2.Aspiration and cough:
Aspiration and cough were relieved completely in all patients.
Surgical technique:
All cases were done under local infiltration anaesthesia2 using 2%xylocaine mixed with1 in 1,00,000 units adrenaline.

Scoring was given to evaluate the voice of the patient as below.

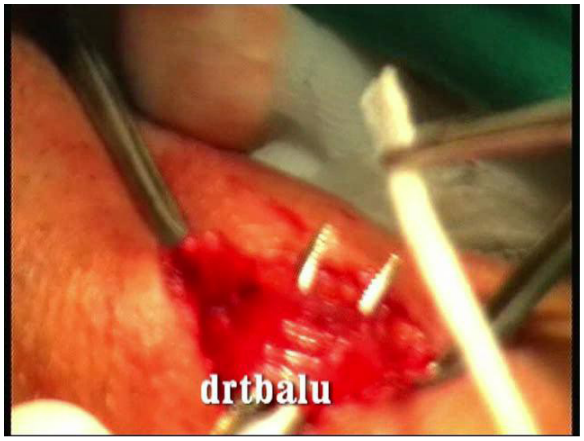
Voice	Original voice	Improved	same	Worse
Scoring	2	1	0	-1

Patients were interviewed and scoring were recorded on 6th post op day.

Voice	Case 1	Case 2	Case 3	Case 4
Scoring	1	2	2	2

Picture showing horizontal skin crease incision

Horizontal skin crease incision beginning at the mid portion of the thyroid cartilage extending to the paralyzed side.



Pictures showing strap muscle separation

The strap muscles are separated away from midline and held apart from the operating field using umbilical tape.

A tracheal hook is used at the level of laryngeal prominence and pulled medially. This helps in mobilizing the cartilage better. The thyroid cartilage perichondrium is incised in the midline and extended laterally towards the paralyzed side.

Picture showing skeletenised thyroid cartilage

The thyroid lamina on the paralyzed side is skeletonized up to the level of cricothyroid membrane. Strips of cricothyoid muscle that come in the way are excised. Dimensions of cartilage cuts3,4: Appropriate size of cartilage window is about 5mm x 10mm. The lower border of the window should be about 3mm above cricothyroid membrane. This ensures that the lower strut of thyroid lamina doesn't fracture when window is being created. Anterior border of the window is 8mm posterior to the midline.

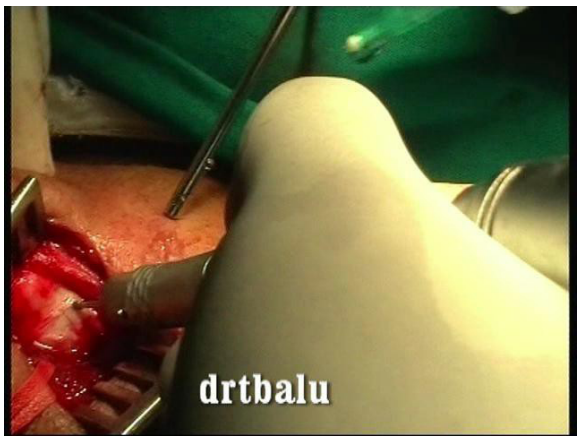


Figure showing creation of window in thyroid cartilage

If thyroid cartilage is calcified then fissure burr can be used to create the window. The inner perichondrium is elevated from the under surface of thyroid lamina using scissors3,4. The inner perichondrium incised posteriorly and inferiorly. It is not incised anteriorly. Now the cricothyroid membrane is incised in order to separate it from the lower border of thyroid cartilage. A septal elevator is introduced through the inferior margin of thyroid lamina and the paraglottic space is compressed medially while the voice of the patient is assessed. If the result is acceptable then 1 cm wide Gor-Tex strips dipped in bacitracin solution is introduced via the inferior margin of thyroid lamina and delivered via the window.

Picture showing Gore tex insertion

The amount of Gor-Tex insertion is dependent on the improvement of quality of voice

Conclusion : Gore-tex implant showed significant improvement in glottal gap closure and loudness. The result persists for 3 to 6 months follow up period.

Discussion: Gore-Tex is a waterproof/breathable fabric, and a registered trademark of W. L. Gore and Associates. a porous form of polytetrafluoroethylene1 (the chemical constituent of Teflon) with a micro-structure characterized by nodes interconnected by fibrils. Gore-Tex materials are typically based on thermo-mechanically Expanded polytetrafluoroethylene (PTFE) and other fluoropolymer products. They are used in a wide variety of applications such as high performance fabrics, medical implants, filter media,insulation for wires and cables, gaskets, and sealants. However, Gore-Tex fabric is best known for its use in protective, yet breathable, rainwear. The outer layer is typically nylon or polyester and provides strength. The inner one is polyurethane, and provides water resistance, at the cost of breathability. The first surgical treatment of unilateral vocal cord paralysis in the modern era was Bruning's intracordal injection of paraffin in 1911.

In 1915 Payr introduced anteriorly based thyroid cartilage flap.Each procedure produced only limited success. In 1960s the first synthetic material, teflon was used for vocal fold injection for medialization. Several authors then introduced different modifications but the procedure did not become popular until the late 1970's when Isshiki introduced his thyroplasty technique. This involved displacing and stabilizing a rectangular, cartilaginous window at the level of the vocal cord, therefore pushing the soft tissue medially. This technique gained wider acceptance after Isshiki reported the successful use of Silastic as the implant material. This procedure has been modified by many surgeons by using different prosthesis. In 1996 hoffman and Mc Cullouch reported the first case of medialization thyroplasty using Gore tex material.
There are some notable advantages to the Gore tex material. The flexibility of the ribbon allows the surgeon to distribute the degree of medialization differently along the length of the vocal fold. Thus alllowing finely tuned intraoperative adjustments that do not involve removal and replacement of the entire prosthesis. This flexibility also allows the surgeon to fit the ribbon through a small cartilage fenestration. The Gore tex implant does not require carving ,is relatively easy to place,and its malleability permits contouring of the surrounding tissue. Greater pliability also may decrease extrusion potential and make Gore tex a more naturel implant for vocal fold augmentation. Because of these unique properties inherent to the material itself , and the case of surgical placement , indications for thyroplasty may be expanded to include almost any anatomic defect at the glottic level that leads to aerodynamic glottic insufficiency.

Drainage system of paranasal sinus a review

Introduction:

Study of drainage system of paranasal sinuses is important in the present day context of Functinal endoscopic surgery and Baloon dilatation techniques in managing sinus infections and ostial obstruction. These minimally invasilve tools have thrown further light into the drainage pattern of various paranasal sinuses.
The following are the documented various racial variations:

The volume of maxillary sinus varies between races and sexes
White population has a higher incidence of concha bullosa of middle turbinate and paradoxical bending of middle turbinate when compared to that of other races
Infra orbital / suprabullar cells are commonly seen in white races
Sphenoethmoidal cells are commonly seen in chinese
Bent uncinate process and complete absence of sinuses are common in chinese

Studies have revealed extensive intercommunication between various paranasal sinuses. It can be safely construed that all paranasal sinuses in addition to their major drainage channel also contains openings connecting one with the other.

Development of nose and paranasal sinuses:

Study of embryology of nose and paranasal sinuses will go a long way in enhancing our understanding of the drainage patterns of various paranasal sinuses. The whole nasal cavity and adjoining paranasal sinuses develop from a cartilagenous anlage called the nasal capsule. This nasal capsule appears between the 7th and 8th weeks of embryonal life. The first area where this cartilage begins to develop is in the nasal septal area. The lateral nasal wall develops much later. The following are the chronology of development of lateral nasal wall:

The cartilage of inferior turbinate develops during the 8th week of gestation
Middle turbinate begins its development during the 9th week of gestation
Superior turbinate begins to develop during the 12th week of gestation.
Uncinate begins to develop during the 9th week
Ethmoidal bulla begins its development during 12th week
Anterior ethmoidal cells starts their develoment during 22nd week
Posterior ethmoid cells begin their development during 40th week

The nasal capsule has tight connections to its surroundings, especially to the cartilagenous anlage of body and minor ala of sphenoid bone. This factor helps in the normal development of sphenoid bone thus ensuring normal develpment of sphenoid sinus.

Expansion of mucous membrane forms the paranasal sinuses. The first air filled sacs in the ethmoid bone begins from the bulla ethmoidalis area. Bulla ethmoidalis gives rise to anterior and middle ethmoid air cells. Ventral to anterior ethmoidal cells the developing primordial ethmoidal infundibulum extends infero laterally towards the inferiorly placed precursor of maxillary bone. This forms the primordial maxillary sinus. At birth only the ethmoid and rudimental maxillary sinus are present. The frontal and sphenoid sinus develops after birth due to gradual pneumatization of frontal and sphenoid bones respectively.

During the process of pneumatization mucous membranes encounter each other. When this happens the underlying mesenchymal layer may disappear causing intersinus communications to form. Eventhough these channels of communication plays very little role in ventilation and drainage of sinuses infections can spread to other sinuses via these channels.

Frontal sinus: May show three types of drainage patterns.

Direct drainage via frontal recess
Drainage via ethmoido nasal route
Drainage via ethmoido maxillary route

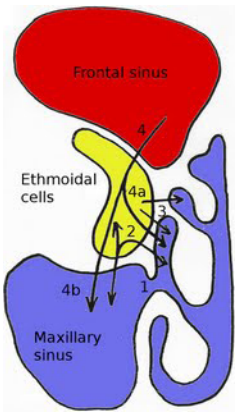
Multiple drainage patterns are commonly seen in frontal sinus. Direct drainage is seen only in a fraction of patients. If the frontal sinus drains directly via frontal recess presence of anterior ethmoidal cells can cause obstruction to drainage of frontal sinus leading on to frontal sinus infection
Ethmoidal cells:

These cells drain directly via upper / middle meatus.
These cells may share common drainage channel with maxillary sinus
These cells may drain via maxillary sinus

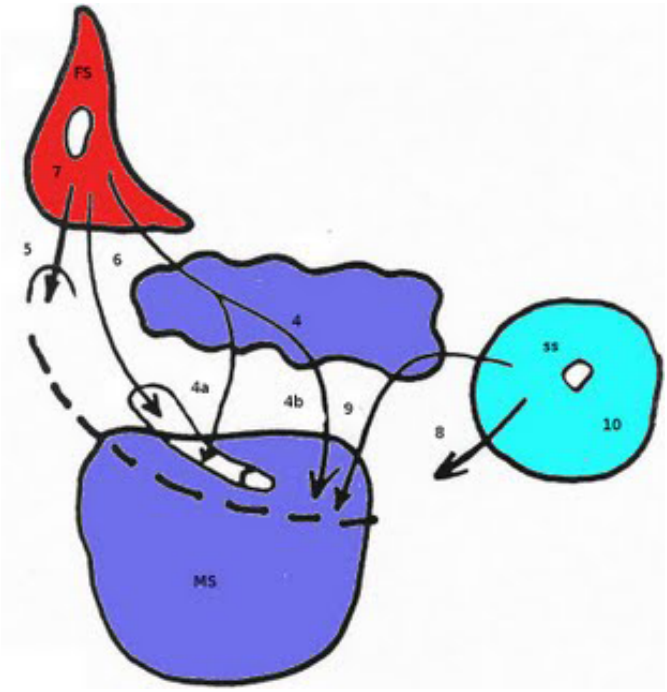
Sphenoid sinus:

Drains directly into the nasal cavity.

Natural ostium / accessory ostium of maxillary sinus
Maxilloethmoid nasal route
Nasal ostia of ethmoidal sinus
4a. Ethmoideo-nasal route
4b. Ethmoideo-maxillary route



Coronal view showing various drainage patterns



Saggital view showing the drainage patterns of paranasal sinuses

Fs – Frontal sinus
Ms- maxillary sinus
Ss- Sphenoid sinus

The following points should be borne in mind before performing Balloon sinuplasty / FESS procedures for chronic sinus infections:

Accessory sinus ostia exist for each paranasal sinuses
Many sinuses do not drain directly into the nasal cavity but indirectly drains via adjacent sinuses. For example sphenoid sinus drains both via posterior ethmoidal cells and directly into the nasopharynx.
Major drainage pathway of frontal sinus is over the ethmoidal sinus, via the ethmoids into the maxillary sinus and then into the nasal cavity
These pathways are not normally accessible during normally performed endonasal surgeries. Inadvertant manipulation can cause fractures of thin septa between these sinuses thereby impairing normal drainage patterns
Presence of secondary / accessory ostia is a definite sign of chronic sinus infection
Presence of accessory / secondary ostia ensures recirculation of mucous due to mucociliary mechanism which tends to beat towards the natural ostium
If accessory ostium is present Balloon sinuplasty invariable ends up dilating the accessory ostium instead of natural one.
It makes real sense if these drainage patterns could somehow be ascertained prior to surgical procedure instead of performing blind dilatation.